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# THE ECONOMY OF STEAM POWER ON COMMON ROADS,

IN RELATION TO

AGRICULTURISTS, RAILWAY COMPANIES, MINE AND COAL OWNERS, QUARRY PROPRIETORS, CONTRACTORS, &c.,

WITH ITS

## History and Practice in Great Britain,

BY

CHARLES FREDERIC T. YOUNG, C.E.,

*(Mem. Soc. Engineers),*

AND

## ITS PROGRESS IN THE UNITED STATES,

BY

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ILLUSTRATED WITH ENGRAVINGS BY J. H. RIMBAULT.

NEW YORK: APPLETON & CO., BROADWAY.

LONDON: ATCHLEY & CO., 106, GREAT RUSSELL STREET

LONDON:

PRINTED BY ROBERT EDWARD PALMER, AT THE SCIENTIFIC PRESS,
5, SALISBURY STREET, STRAND.

TO

AN ENLIGHTENED PUBLIC,

IN

THE HOPE

OF

MEETING WITH THEIR APPROVAL AND SUPPORT,

This Work

IS RESPECTFULLY INSCRIBED,

BY

THEIR OBEDIENT SERVANT,

THE AUTHOR.

# PREFACE.

"Railroads are useful for speed, and for the sake of safety, but *not otherwise;* EVERY PURPOSE WOULD BE ANSWERED BY STEAM ON COMMON ROADS, WHICH CAN BE APPLIED TO EVERY PURPOSE A HORSE CAN EFFECT."—*Trevithick.*

IN treating on the subject of the Economy of Steam on Common Roads, and for agricultural operations generally, which at present is attracting much and anxious attention in this country and abroad, I have endeavoured to give a statement of its advantages, such notice as has been thought necessary of the various attempts hitherto made to accomplish this desirable object, the reasons which have led to their failure, and the reasons why up to the present time, Steam Traction is not more general in this country.

In carrying out Steam Locomotion on Common Roads, the principles adopted by those who have practically gone into it, are divided into two systems —one that of "*Concentrating*" the heavy weight of the engine on a *small bearing surface*—and the other, that of "*Distributing*" this weight over a *large surface*; and it will be seen how these plans work out in practice.

It has been preferred, where practicable, to give *plain facts* rather than theoretical reasons, in order

that all who are more readily convinced and satisfied by *facts*, may herein find such information and particulars as may be required. It has also been desired to bring the latest facts obtained from the actual working of Steam Engines on Common Roads before the public, so as to enable them to form an idea of the merits and demerits of the two systems here treated of, and to prevent the failure of one plan prejudicing the use of Steam Traction, and causing great disappointment and expense to such as, from want of practical knowledge on these matters, and not being aware of what is being and has been done, are too apt to be deceived by appearance, and only learn by dear-bought experience what others, who have been accustomed to the matter, already know from actual practice.

The section containing the History of Steam on Common Roads in the United States, has been prepared by Alexander L. Holley, Esq., C.E. (well known in connection with Zerah Colburn, Esq., C.E., as joint author of "European Railways"), and John K. Fisher, Esq., a practical engineer of New York, who has given much attention to this subject for some years past.

C. F. T. Y.

5, *Adam Street,*
*Adelphi, London.*
*Nov. 1st,* 1860.

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# TRANSPORT.

The importance of a cheap and regular system of land carriage to the prosperity of a country, is of the highest moment, and requires the most serious attention of those with whom its development rests, to carry it out in a proper manner.

Next to the general influence of the seasons, upon which the regular supply of our wants, and a great proportion of our comforts so much depend, there is perhaps no circumstance more interesting to men in a civilised state than the perfection of the means of interior communication; and it is at once evident, that in whatever country these means are most imperfect, or where, from a deficiency of "pecuniary power," the construction of canals or railroads—both of which in foreign countries are found to be very expensive to construct, and equally so to maintain—cannot be carried out, a cheap, simple, and efficient means of using to the best advantage, such lines of traffic as will admit of the use of the giant

power of steam, cannot fail to be looked upon as a great and important benefit.

M. Storch, in his "Cours d'Economie Politique," Vol. I., p. 188, says, that "after giving protection to property and person, a government can bestow on a nation no greater benefit than the improvement of its harbours, canals, and roads."

The author of the "Wealth of Nations" says: "Good roads, canals, and navigable rivers, by diminishing the expense of carriage, put the remote parts of a country nearly on a level with those in the neighbourhood of a town: they are, upon that account, the greatest of all improvements."

A writer in the first volume of "Communications to the Board of Agriculture" remarks, and with great truth, that "the conveniences and beneficial consequences which result from a free and easy communication between different parts of a country are so various, the advantages of them so generally and so extensively felt by every description of individuals, from the highest to the lowest, that no labour or expense should be spared in providing them. Roads, canals, and navigable rivers may be justly considered as the veins and arteries through which all improvements flow. How many places, in almost every country, might be rendered doubly valuable if access to them were practicable and easy."

The Abbé Regnal forcibly remarks :—"Let us travel over all the countries of the earth, and whenever we shall find no facility of travelling from a city to a town, or from a village to a hamlet, we may pronounce the people to be barbarians."

The civilised world owes to the Romans the first establishment and example of a commodious intercourse—one of the greatest aids of commerce and means of improvement that society can enjoy.

Mr. Pinkerton observes, that "one of the grand causes of the civilisation introduced by the Romans into the conquered states was the highways, which form indeed the first germ of national industry, and without which neither commerce nor society can make any considerable progress. Conscious of this truth, the Romans seem to have paid particular attention to the construction of roads in the distant provinces; and those of England, which may still be traced in various ramifications, present a lasting monument of the justice of their conceptions, the extent of their views, and the utility of their power."

Mr. Eustace, in his "Classical Tour," after having shewn that the civilised world owes to the Romans the first establishment and example of a commodious intercourse, further says: "The barbarians who overturned the Roman power, were for many ages so incredibly stupid as to undervalue this blessing, and

almost always neglected, and sometimes wantonl destroyed, the roads that intersected the province which they had invaded."

Spain, Portugal, Sicily, and Greece, are still s immersed in barbarism as to leave the traveller t work his way through their respective territories witl infinite fatigue and difficulty, by tracks and path often almost impracticable.

The *Edinburgh Review* for July, 1832, in speaking of the roads of Spain at that period, says: "Anothe check upon agriculture is, that with the exception o some few high roads, which are sufficiently insecure, there exists scarce a waggon or cart track throughout Spain. All means of transport are therefore dear; and in Salamanca it has been known, after a succession of abundant harvests, that the wheat has actually been left to rot, because it would not repay the cost of carriage!" This state of things is not much improved at the present time.

It is only within the last hundred years that the roads of our own country have been brought into a decent state; and the following extract from "M'Culloch's Dictionary of Commerce" gives a pretty idea of the state of things during that period: "It is not easy for those accustomed to travel along the smooth and level roads by which every part of the country is now intersected, to form an accurate

idea of the difficulties the traveller had to encounter a century ago.

"Roads were then hardly formed, and in summer not unfrequently consisted of the bottoms of rivulets. Down to the middle of the last century, most of the goods conveyed from place to place in Scotland—at least, where the distances were not very great—were carried, not by carts or waggons, but on horseback. Oatmeal, coals, turf, and even straw and hay, were conveyed in this way. At this period, and for long previous, there were a set of single horse traffickers (cadgers) that regularly plied between different places supplying the inhabitants with such articles as were then most in demand, as salt, fish, poultry, eggs, earthenware, &c. These were usually conveyed in sacks or baskets, suspended one on each side of the horse; but in carrying goods between distant places it was necessary to employ a cart, as all that a horse could carry on his back, was not sufficient to defray the cost of a long journey. So late as 1763 there was but one stage coach from Edinburgh to London, and it set out only once a month, taking from twelve to fourteen days to perform this journey!"—a distance now accomplished daily in the same number of *hours*.

Arthur Young, in his "Six Months' Tour," gives a very pleasant description of the state of the roads

in the north of England in 1770, which will prove interesting to my readers of the present day.

In foreign countries, especially in South America, the only means at present in use for the transport of goods and merchandise from place to place, where water carriage is not available, is on the backs of mules or horses, or in small carts or sledges drawn by bullocks or other animals, in consequence of which the transport of goods becomes very expensive, and is also limited to small weights, seldom exceeding 3 cwt.; so that inland, or away from water carriage, transport becomes very expensive. A striking example of the clog this state of things puts on the energies of a country when they have no other means of internal intercourse, was shewn in the mania for mining speculations in South America in 1825.

Some of these mines were situated at some distance in the interior, and it was considered that there could be only one drawback to their being successfully worked, and that would be the want of proper machinery for working them. In order to supply this deficiency, large and heavy iron castings, &c., for the machinery were sent out from this country; but when they were put on shore, the only means for taking them to the mines was found to be the *backs of mules*—a means utterly unfitted for the purpose; and in consequence they were left on the shore com-

pletely useless. This occurrence, I may remark, was not by any means a solitary instance, nor confined to the year 1825, similar performances having several times taken place within the last few years.

The measures necessary to be taken for affording the means of travelling rapidly and safely, and of transporting or carrying goods and merchandise, in quantities or large masses, at low rates of carriage, form an essential part of the domestic economy of every people; and as the making of roads is fundamentally essential to bring about the first change that every rude country must undergo in emerging from a condition of poverty and barbarism, it becomes one of the most important duties of every government to enact such laws, and provide such means as are required for this purpose, and the making and maintaining of well-constructed roads, or other means of communication into and throughout every portion of the territory under its authority.

Easy communication lessens the time occupied in transport; saving of time shortens the distance and saves money; saving money permits of a greater employment of capital; and whatever reduces the cost of transport reduces the price of the commodity transported.

In proportion as roads are level and hard, there

will be a saving of horse labour; fewer horses will be required; they will last longer; a cheaper description of horse may be employed; less food will be consumed; fewer servants will be wanted. In consequence of this reduction of expense, the charges for travelling will be reduced, and also the rates for the carriage of goods. An aggregate saving of expense to the public will thus annually take place, amounting to a considerable sum, either to be applied to other expenses, or to the accumulation of the national capital.

Colonel Torrens, in his evidence in the House of Commons, in 1831, on the subject of Steam on Common Roads, remarked: "That agriculture is prosperous in proportion as the quantity of produce brought to market exceeds the quantity expended in bringing it there. There are many tracts of land which cannot now be cultivated, because the quantity of produce expended in cultivation and in carriage exceeds the quantity which that expenditure would bring to market. On the same principle, lowering the expense of carriage would enable you to apply additional quantities of labour and capital to all the soils already under cultivation."

Any plan by means of which transport can be more economically performed, cannot fail to be of the

greatest advantage to those adopting it, and consequently it becomes a great gain to everybody in the end.

In situations where rivers and canals are not available, or cannot be constructed from want of water, or other circumstances, and where the description and quantity of traffic or local obstructions do not justify the expense of forming a railroad, there will the steam traction engine be found the cheapest and most efficient means of transporting heavy goods, at a moderate rate of speed, on the roads already in existence.

Mr. Alexander Gordon, C.E., in his "Treatise on Elemental Locomotion," observes, that "in a great commercial country like ours, extending its ramifications to every branch of natural and artificial produce, it is almost superfluous to remark, that a vast capital is sunk annually in the mere transport of marketable commodities, and which is not only a loss to the seller as being an unproductive outlay, but entails a heavy increase of expense to the buyer also, upon every article of daily consumption."

He also says, in speaking of the advantages to be opened up by steam transport, "that to whatever point of detail we direct our attention, we shall perceive but a very limited view of the benefit, as a whole, which is to arise from the introduction of this

grand agent when it shall be properly economised and brought to bear, in full operation, upon the varied transactions of daily life."

The cheap and regular power of steam, when applied to the purposes of transport, in this or any other country, whether on railroads or common roads, or ways prepared for the purpose, is sure to increase the business of the neighbourhood it gives access to by its facility for communication.

Now, as it has been satisfactorily shewn that every improvement in the means of transport has a tendency to diminish its cost, and that the diminishing of cost stimulates the consumption and production, increasing thereby the wealth and prosperity of the countries adopting them, it only remains to place before those interested in the question such a cheap, simple, and efficient means of transport as shall be able to meet their requirements, in order to make them adopt it.

Let us look, for example, at the late mutiny in India, and see the great advantage a system of transport—which would have brought a large body of troops, guns, provisions, &c., to any point required, even if not at a greater rate than they could have marched—would have been. The men would thus have been fresh for action on arriving at their journey's end. The importance of such a system for military affairs has long been acknowledged, but

nothing—or at least, very little—seems to have been done towards obtaining it.

See, also, the small amount of profitable operations, of an agricultural nature, that have been established in India. One great impediment has been—and I think I may say, none greater—than the want of a cheap and certain means of transit. Agricultural produce and merchandise are of small value if they cannot be easily conveyed from place to place, and brought cheaply to their proper markets.

To bring the appliances of western science and art to bear on the various industries of our immense eastern territories, to stimulate production there, and introduce all available facilities for locomotion, and the easy transmission of goods and persons,—these are the first steps to be taken for the creation of adequate wealth and revenue, and should be the first aim of those in authority in that or any other country.

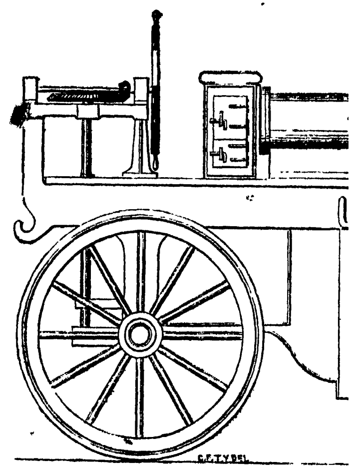
Until the close of the last century, the internal transport of goods in England was chiefly performed by waggons, and was not only fearfully slow, but so very expensive as to exclude every object except manufactured articles, and such as, being of light weight and small bulk in proportion to their value, could bear the cost of a high rate of transport. Thus, for instance, the charge for carriage by waggon from London to Leeds, was at the rate of £13 a ton,

being 1*s.* 1½*d.* per ton per mile. Between Liverpool and Manchester it was 40*s.* a ton, or 1*s.* 3*d.* per ton per mile.

Heavy articles, such as coals and other materials, could only be available for commerce where their position would favour transport by sea; thus many of the richest districts in the kingdom remained unproductive, awaiting the tardy advancement of the art of transport. Notwithstanding the introduction of stage coaches in the seventeenth century, they were placed only on the principal roads, and used almost exclusively by persons of refined taste and wealth.

The popular mode of conveyance continued for at least a century afterwards to be by stage waggons. These were very large and cumbersome machines, drawn by six or eight horses, and devoted chiefly to the carriage of goods to and from the metropolis. The only part of the vehicle which afforded accommodation to passengers was the tail of the waggon, as it was called—a reserved space with a hooped-up cover at the hinder part of the machine; and here, sitting upon straw, as they best could, some half dozen passengers were slowly conveyed on their journey.

The chance attacks of highwaymen, and other incidents which occurred to the occupants of the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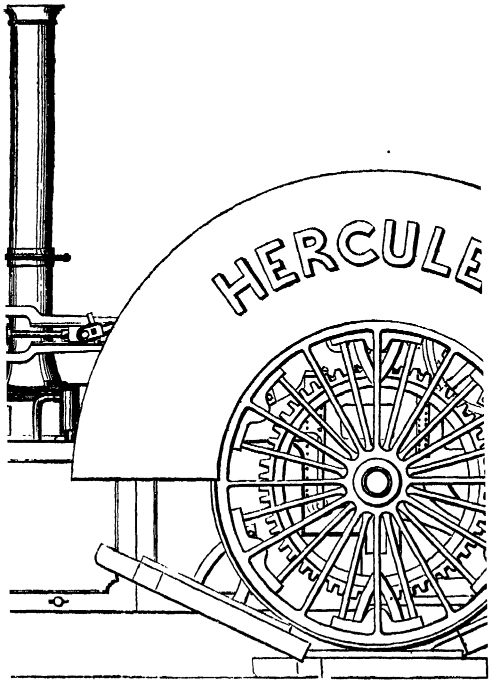
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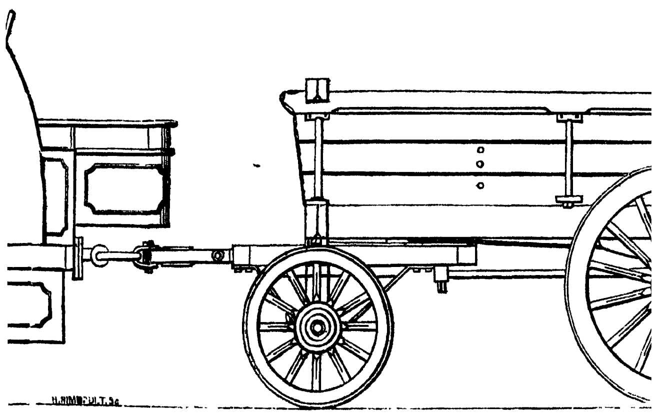
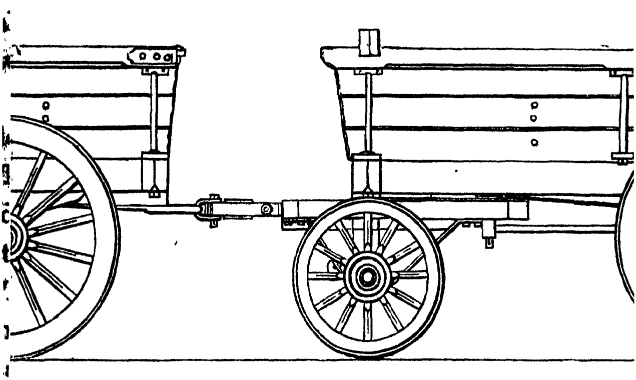
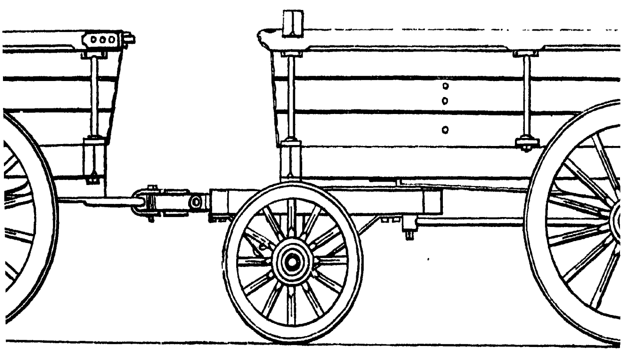
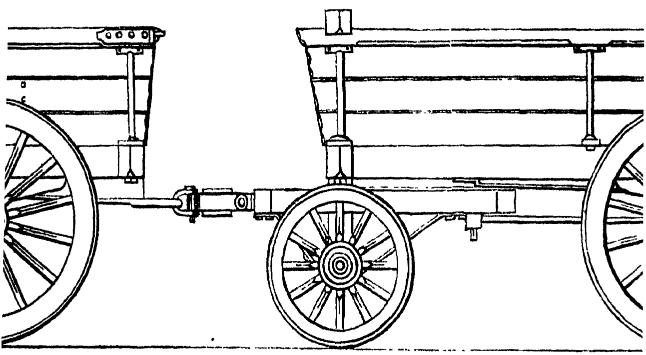




ıYDELL'S TRACTION ENGINE AND ENDLESS RAILWAY, AN



WAGGONS, AS USED AT THE COLLIERIES AND ELSEWHERE.—1



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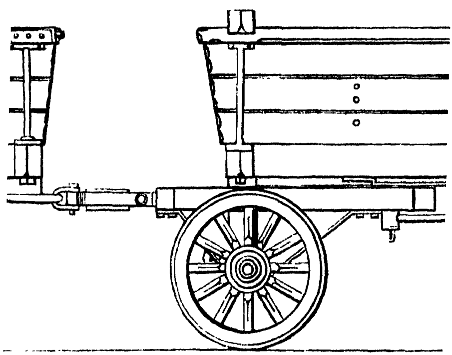

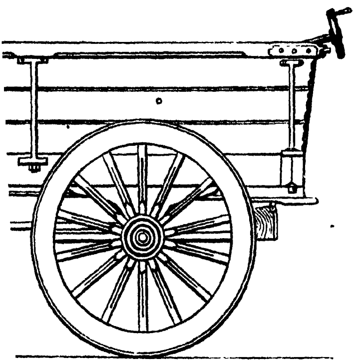

waggon, and also their adventures at the inns where they slept for the night, are capitally described by Smollet in his story of "Roderick Random," as will be remembered by most of the readers of this.

The waggon was for some time patronised by persons of distinction, for one of the Dugdales of Warwickshire writes: "March 16th, 1660. My daughter Lettice went towards London in a Coventry waggon."

M. Sabiere, a French man of letters, who soon after this came to England for the sake of an introduction to Charles the Second, and also to visit some of our distinguished literary characters, thus describes the mode of his conveyance from Dover to London: "That I might not take part, or be obliged to use the stage coach, I went in a waggon. It was drawn by six horses, one before another, and drove by a waggoner who walked by the side of it."

The waggons thus employed in the double office of carrying both goods and passengers, were, as before stated, confined chiefly to the great lines of road in England. A few remnants of these huge unwieldy vehicles, drawn at an immense and wasteful expenditure of power, may occasionally be seen lumbering along our streets loaded with coals, or with barrels of beer, from some wharf or brewery.

One of the consuls in Peru, describing the state

of the country from the want of some efficient means of transport, says: "Metals are plentiful in the province—tin, silver, copper, iron, and platina; and there are also gold washings. The scarcity of skilled labour, and the high rate of wages paid for any sort of provisions, or fuel, or water, which have frequently to be conveyed for leagues *on the backs of animals*, making a fearful addition to the prime cost, all tend to deter persons from entering into speculations."

In another instance, quite recently, it has been stated that in constructing a bridge on a railway in the Brazils, in an inland spot some distance from the shore, *all* the coal, iron, steel, and lime, together with the supplies of food, had to be carried to the spot *on the backs of mules;* and from the expenses and difficulties attendant on the want of a more efficient means of transport, the construction of this cut stone bridge, with a chord of 52 feet, and a versed sine of 9 feet, occupied nineteen months of incessant labour, and cost £24,000!

It has been said, that "give India abundant and cheap means of transport, with European agency and appliances, and she can clothe the world in cheap cotton." When the locomotive and the steamboat are substituted for the wretched pack bullock and groaning hackery, then, and not till then, will India be justly valued and understood.

So inconvenient and inefficient are the present means of transport in that country, that it has been said of a certain place, "until the communication between it and the river is greatly improved and cheapened, the large demand and high cost of carriage from the river, will render it profitable to import grain from places which, with better facilities for transport, might themselves be supplied from these extensive grain producing provinces."

Colonel Cotton has observed, that "speed in forming communications is of more importance to India than speed in travelling on them."

The *Times*, in a leading article on the late mutiny in that country, remarked: "The time has arrived when the power of transporting compact and highly trained bodies of European troops from one point of India to another, may be all important." I think the truth of this was never more apparent than throughout the whole history of that detestable affair.

The quicker means of easy communication are provided, the more rapidly will that country rise in importance, and the more certainly and firmly will our rule there be ensured. At present, great efforts are being made to carry out the railway system in that country, and it is highly desirable that they should be; but still years must elapse before one-tenth part of what is needfnl can be done; and

having seen, during the mutiny, the severe want of adequate means of internal communication, it is evidently a subject that will admit of neither expense or trouble being considered in carrying it out as expeditiously as possible.

The present cost of locomotion in India is immense. During the campaign in the Punjab it was estimated that every man in the British army had cost £150; and of course as much would be required to replace him if he were killed or disabled. The usual allowance on an Indian line of march is one camel to two fighting men; and, including the other items of elephants, bullocks, horses, and camp followers—which are always connected with the armies of the East, and which swell the array to an enormous and unwieldy mass,—the expense is prodigious. Omitting everything, however, but the camels, an idea may be formed of the cumbrousness and cost of an army composed of such materials.

Such instances as the above prove most incontestably how important a matter transport becomes in foreign lands, and what constant care and attention it requires to give it every facility and advantage for its development, as well as no small amount of judgment and experience in arranging and carrying out a systematised detail.

# ROADS.

It is now generally allowed, that the Romans gained a certain degree of knowledge on the subject of road-making from Greece and Carthage, and possibly, also, from Egypt; but whatever they learned they greatly improved upon, and therefore they are entitled to be called the first and best road-makers of whom history has preserved any account.

The chief great leading principle which actuated the Romans in establishing roads, was that of maintaining their military conquests. Having vanquished a barbarous country, their first efforts were directed to piercing and intersecting it with good roads, and in maintaining them with jealous care. These roads were connected, as far as possible, in unbroken lines with the seat of government at Rome, and formed one of their greatest engines of subjugation; and we have in this, a striking proof of their sagacious and active character.

If we carefully trace the distance from the wall of

Antoninus in Scotland, to Rome, and from thence to Jerusalem, it will be found that the great chain of communication, from the north-west to the south-east point of the empire, was drawn out to the length of 4080 Roman, or 3740 English miles.

Their public roads were accurately divided by mile-stones, and ran in a direct line from one city to another, with very little respect for the obstacles either of nature or private property: in this respect shewing a strong resemblance to the railways of the present day. Such was the solid construction of the Roman highways, that their firmness has not entirely yielded to the effect of fifteen centuries.

Various remains of Roman roads of this kind still exist in France, and also in different parts of Britain. One of the chief Roman thoroughfares, in an oblique direction across the country from London to the western part of Scotland, was long known by the name of Watling Street, which has been perpetuated in the appellation of one of the streets in the metropolis.

It appears that from the time the power of the Romans began to diminish in this country, that the roads were kept in a less efficient condition; and there seems to have been no art in which our ancestors were more deficient or careless, than in that of making roads and keeping them in repair; and

all readers of history will agree that they were in a condition of greater ignorance than the ancient Romans.

Attempts however, were made to improve the roads forming the leading thoroughfares in England, at the beginning of the eighteenth century; and for that purpose, turnpike acts for various districts were passed by parliament.

A proclamation of Charles the First, issued in 1629, confirming one of his father's in the twentieth year of his reign, for the "preservation" of the roads of England, will give a tolerable idea of their state at that period. It commanded "that no carrier or other person whatsoever shall travel with any waine, cart, or carriage, with more than two wheels, nor above the weight of twenty hundred, nor shall draw any waine, cart, or carriage, with more than five horses at once."

The first turnpike road was established by law, by the 16 Charles II., cap. i., anno 1653, for taking toll of all but foot passengers, on the northern road, through Hertfordshire, Cambridgeshire, and Huntingdonshire, the road having become very bad by means of the great loads of barley and malt, &c., brought weekly to Ware in waggons and carts, and from thence conveyed by water to London.

It was not, however, till after the peace of 1748

that anything like a great exertion was made to redeem the public highways from the wretched state in which they had always been. Under "Transport," I have shewn a few instances of the condition in which they then were; and any work treating on transport or travels through this country for the last three hundred years, will shew the miserable state into which they had fallen.

The plan on which the attempts to "improve" the roads were carried out, generally resulted in making them far worse, and often rendering them impassable. All these attempts at improvement were only partial, for as yet the proper mode of road-making was not understood. They generally endeavoured to make their roads or paths a little more level, and then filled up the ruts and holes with stones gathered from the adjacent fields—a plan still followed in most of the rural districts of this country.

By this means, the holes, ruts, and sloughs were considerably limited, both in breadth and depth; but as a perfect, or even an approximate level was not attained, carriages and carts were alike dreadfully jolted over the rougher parts, and the wheels sunk jarringly into the softer ground beyond;—all of which operations must evidently be highly conducive to the economical maintenance of both power and rolling stock.

In laying down these stones, no pains were taken to lay them down of equal size, but down they went, large and small indiscriminately; and as a necessary consequence, it followed that the larger ones in time worked to the surface, thus creating additional jolting to the vehicles, and damage to the road. I have often seen ruts varying from six to twelve inches deep in these roads, in the country; and the pleasure experienced in travelling over a few miles of such roads can easier be conceived than described.

The old proverb says: "When things come to the worst they mend;" and so in this instance: the "worst" arrived, and as a remedy, appeared the well-known James Loudoun M'Adam, to whose skill and exertions we are indebted for our present efficient roads, and the system of "macadamising" through which he has immortalised his name, and conferred a lasting benefit on the inhabitants of this country and the civilised world.

Mr. M'Adam was born on the 21st September, 1756, in the town of Ayr, and received his education at the school of Maybole. On the death of his father in 1770, when he was only fourteen years of age, he was sent to New York, to his uncle William, who was a merchant in that city. He remained here fourteen years, during the war of independence, and under British protection he realised a considerable

fortune. At the conclusion of the war, having lost nearly the whole of his property, he returned to his native country.

In the year 1798 he received the appointment of agent for victualling the navy in the western parts of Great Britain, and removed in consequence to Falmouth. Whilst thus engaged in duties of an entirely different kind, he first turned his attention seriously to the mechanical principles involved in the process of road-making, and continued to study, in all its details, that branch of national economy, keeping particularly in view the great desiderata of a compact and durable substance and a smooth surface.

Mr. M'Adam was the first to point out and prove, in practical operation, that a bed of a few inches in depth, formed of fragments of primitive rock, granite, greenstone, or basalt,—small enough to pass through a ring not larger than two and-a-half inches in diameter,—was the best material for ordinary roads. His system, in its leading features, is so conspicuously displayed to the public eye, that any minute account of it would be superfluous.

It was not, however, until the year 1815, when on the borders of sixty, that he began to devote his whole mind to the business of road-making. At this period, being appointed Surveyor-General of the Bristol Roads, he had at length full opportunities of

exemplifying his system, which he forthwith proceeded to do in a manner that attracted general attention, and caused it to be quickly followed throughout the whole kingdom.

In 1823 he was examined before a Committee of the House of Commons respecting the propriety of converting the granite rubble causeway of the principal thoroughfares into a smooth pavement, resembling those which he had already formed on the principal roads. He expressed himself decidedly of opinion that such a change should be made, and in consequence some of the principal lines of streets in London, Edinburgh, and Dublin, which had been previously remarkable for solidity of pavement, as well as the large sums that pavement had cost, were, to use a familiar phrase, macadamised.

Having expended several thousand pounds from his own resources in introducing this improvement into British roads, in 1825 the House of Commons—he having proved this to the satisfaction of a committee of the House—voted him an equivalent sum, besides an honorary tribute of £2000, in "consideration of the public benefits resulting from his labours."

The inadequacy of this remuneration is very striking and significant, and one cannot avoid contrasting it, in some bitterness of spirit, with the

ratio in which services of other and less beneficial kinds,—sometimes, too, of a rather questionable nature,—are usually acknowledged. But though the remuneration was thus small, and never, as it has been stated, fully paid, Mr. M'Adam would have been the last to complain of it. He never made money an object, but, on the contrary, rejected on principle, many opportunities of gathering wealth which his office as superintendent opened up to him, and which many men, of by no means blunt feelings as to professional propriety, especially at the present day, would have taken advantage of. He therefore died a poor, but as he frequently expressed himself, "at least an honest man," on the 26th November, 1836, at Moffat, at the good old age of eighty-one years.

The principles of road-making, as introduced and acted upon by Mr. M'Adam, consisted in the constructing of an artificial and hard flooring on a level and dry surface. From this it will be evident that, in order to make a good road, the first step must be to level and prepare the ground.

Mr. M'Adam says, "Roads can never be rendered perfectly secure until the following principles be fully understood, admitted, and acted upon; namely, that it is the natural soil which really supports the weight of travel; that while it is preserved in a dry state it

will carry any weight without sinking; and it does, in fact, carry the road and carriage also; that this native soil must previously be made quite dry, and a covering, as much impenetrable to rain as possible, must then be placed over it, to preserve it in that dry state; that the thickness of a road should only be regulated by the quantity of material necessary to form such impervious covering, and never by any reference to its own power of carrying weight."

Roads may be divided into the following varieties:—

1. Paved roads.

2. Roads of which the surface is partly paved and partly made with broken stones or other materials.

3. Roads with a foundation of pavement, and a surface of broken stones.

4. Roads with a foundation of rubble stones and a surface of broken stones or gravel.

5. Roads made with broken stones laid on the natural soil.

6. Roads made with gravel laid on the natural soil.

As the three last may be considered to be one or other of the plans most easy to be followed out in practice, I shall in the following remarks allude to them entirely—the others being only adapted for

for peculiar circumstances, where expense is not of any great consideration.

The following principles have been found to work well in practice, and as they have the authority of Sir Wm. Parnell and others who have been more or less engaged in laying out roads, they have become established, so I make no apology for giving a condensed summary of them, feeling sure that they will be found useful.

In some of our rural districts they will certainly be of use, road-making being in a very primitive state, and any good system of procedure quite unknown; and as it is possible this book may find its way into such a *locale*, I think they may there be found useful.

The business of tracing the line of a road should never be undertaken without the assistance of iustrnments; and all local suggestions should be received with extreme caution.

To guard against errors in this important point, it is essentially necessary not to trust to the eye alone, but in every case to have a survey made of the country lying between the extreme points of the intended new road. For this purpose an experienced surveyor should be employed to survey and take the levels of all the various lines, that on a previous perambulation of the country appear favourable. It is

only by such means that the best line can be determined.

It may be laid down as a general rule, that the best line of road between any two points will be that which is the shortest, the most level, and the cheapest of execution. But this general rule admits of much qualification, and it must, in many cases, be governed by the comparative cost of annual repairs, and the present and future traffic that may be expected to pass over the road. Natural obstructions also, such as hills, valleys, and rivers will intervene, and frequently render it necessary to deviate from the direct course.

When hills are high and numerous, it sometimes appears from a perambulation and inspection of the country to be advisable to leave the straight line altogether from the beginning, in order to cross the ridges at lower levels by a circuitous course. It constantly happens that although inclinations which do not exceed the prescribed rate can be had without quitting the straight line, the ridges may be crossed at many feet of less perpendicular height, by winding the road over lower points of them; but the propriety of doing so will depend upon the length that a road will be increased by going round to avoid passing the ridges in the direct line. The saving of perpendicular height to be passed over by a road,

though a matter of so much importance and practical utility, has not hitherto received that attention from engineers which it deserves. For this reason it has been deemed advisable to bestow some investigation on it.

When expeditious travelling is the object, such as is to be gained by the employment of steam coaches, the maximum inclination, which should never, unless unavoidable, be exceeded, is that which will maintain the power of the carriage or engine at as nearly a uniform average throughout the journey as possible, and therefore this desirable end is easiest attained by reducing the gradients to one fixed standard, and as carriages on wheels, whether propelled by steam or drawn by horses, are necessarily retarded in ascending hills, however moderate their inclination may be, if the descending gradient be not such that they can be safely driven down it at a good rate of speed without danger, a great loss of time is the result. This circumstance is particularly deserving of attention, inasmuch as it gives the easiest means of maintaing an average fast rate of speed over a given length of road, and the best gradient for this purpose, and one which should not be made steeper, is 1 in 35; and the more this gradient is reduced over a given length of road, the greater and more satisfactory will be the results of the power employed on it.

It should be remembered that in ascending heavy gradients there is not only the loss arising from the additional power required to surmount them, but in descending them the retarding power of the drag becomes necessary, and that, besides the injury done to the road or ground, there is the loss of time caused by stopping to put it on and take it off, which, when these stoppages occur frequently on a long journey, must be attended with corresponding loss, and should therefore, wherever practicable, be carefully avoided.

An inclination of 1 in 35 has been found by experience to be just such an inclination as admits of the horses in a stage coach being driven down it in perfect safety at as fast a trot as they can go, and the driver is easily able to preserve his command over them. For this reason it may be taken as a general rule in laying out a new line of way or road, that it should not, if possible, have a greater inclination than 1 in 35. Particular circumstances may no doubt occur, requiring a deviation from this rule, but nothing except a clear case that the circuit to be made to gain the prescribed rate would be so great as to require more power and time in drawing over it, than ascending the greater gradient, should be allowed to have any weight in favour of departing from this general rule. On any gradient greater

than 1 in 35 the power expended in ascending, and the use of means of retarding in descending, involve a wasteful expenditure in one case, and damage to the road in the other.

It has been found that the expense of drawing one ton over one mile of each of the following rates of inclination with four horses, at an average velocity of 2½ miles an hour, is as follows :

| | | | d. |
|---|---|---|---|
| On a horizontal surface the expense is | | | 12·36 |
| On one in 500 the expense is | | | 12·69 |
| „ | 300 | | 12·91 |
| „ | 200 | „ | 13·18 |
| „ | 100 | „ | 14·04 |
| „ | 90 | „ | 14·22 |
| „ | 80 | „ | 14·46 |
| „ | 70 | „ | 14·77 |
| „ | 60 | „ | 15·20 |
| „ | 50 | „ | 15·82 |
| „ | 40 | „ | 16·79 |
| „ | 30 | „ | 18·55 |
| „ | 20 | „ | 22·83 |
| „ | 15 | „ | 28·70 |
| „ | 10 | „ | 52·07 |

From this it will be seen how desirable it is to keep the gradients as light as possible, and when they get over one in sixty, how rapidly the expense increases.

Hilly ground, however, is not always to be avoided as being unfit for a road; for if the hills are steep and short, it will often be easier to obtain good

inclinations, or even a level road, by cutting down the summits, and with the materials taken out, filling in the hollow parts. But this must be regulated by the expense to be incurred, which is the main consideration, and one which should always be scrupulously attended to before an engineer decides upon the relative merit of several apparently favourable lines, though I am sorry to say such is not always the case.

A perfectly flat road is to be avoided, if it is not to be raised by embanking at least three feet above the general level of the land on each side of it, so as to expose the surface of it fully to the sun and wind; for if there is not a longitudinal inclination of at least one in a hundred on a road, water will not run off; and in consequence of which, the surface, by being for a longer time wet and damp than it otherwise would be, will wear rapidly away; and the expense of maintaining it in order, by scraping it and laying on materials, will be very much increased.

The great fault of all roads in hilly countries is, that after they ascend for a considerable height, they constantly descend again before they gain the summit of the country which they have to traverse.

In tracing a road across a deep valley between two hills, it should be carried in a direction opposite to the fall of the valley, as by so carrying it, that is, by

crossing the valley at the highest practicable point, the descent and ascent are diminished.

Thus, if in going across a valley it be found by levelling, that in a straight line the valley is too deep to make an embankment at a reasonable expense, a line should be tried higher up the valley, rather than in a direction where it would get into a lower level. Although this is the general principle, instances may occur where a valley may be crossed with more advantage down stream; as, for instance, if the sides of a valley contract considerably, it may require much less embankment to raise the road to the same height, than if it were carried higher up the valley.

A difficulty may arise from the breadth of the river requiring a bridge of extraordinary dimensions, or from the land for a considerable distance on the sides of the river being subject to be covered with water to the depth of several feet in floods.

In these cases it may appear upon accurately calculating and balancing the relative inconvenience and expense of endeavouring to keep a straight line, and of taking a circuitous route, that upon principles of security, convenience, and expense, the circuitous course will be the best.

In general rivers have been allowed to divert the direct line of a road too readily. There has been

too much timidity about incurring the expense of new bridges, and about making embankments over flat lands to raise the roads above the level of high floods.

These apprehensions would frequently be laid aside if proper opinions were formed of the advantages that arise from making roads in the first instance in the shortest directions and in the most perfect. manner. If a mile, half a mile, or even a quarter of a mile of road be saved by expending even several thousand pounds, the good done extends to posterity, and the saving that will be the result in annual repairs and horse labour will, before long, pay off the original cost of the improvement.

The elastic nature of all bogs and marshes, and of all boggy and bottom land, makes it impossible to form a road of perfect hardness over a soil of this kind, unless a great deal of labour and expense is applied in draining the soil, and afterwards compressing it by loading it with large quantities of earth embanked upon it, in order to destroy the elasticity of the subsoil.

Although the surface coating of a road over such a subsoil may be made with a great abundance of the hardest materials, and be perfectly smooth, the porous and moist texture of the subsoil will cause the road to yield to a carriage passing over it; and

thus, by destroying the momentum of it, add greatly to the labour of the horses or other power in drawing it.

For this reason, it will generally be prudent to deviate from the direct line in laying out a new road, if by doing so this sort of subsoil can be avoided without adding much to the length of it. But when the additional length of the road would be considerable, it will then be necessary to incur the expense of proper drainage, and the formation of an embankment heavy enough to compress and harden the moist and porous subsoil. It will sometimes happen that road materials can be better obtained by carrying a line of road in one direction than in another.

This will be a good reason for making a road deviate from the direct line, because the expense of making and repairing it will much depend on the distance which materials have to be carried.

It is necessary, in making a road through a hilly country, to take particular care to give it a proper aspect. It is very advantageous to have a road on the north side of a valley fully exposed to the sun. For the same reason, all woods, high banks, high walls, and old fences ought to be avoided, in order that the united action of the sun and wind may have full power to produce the most rapid evaporation of

all moisture. Too much attention cannot be bestowed on this object, in consequence of the effect of water in contributing to cut and wear down the hardest substances.

It is for this reason that road materials, when they are wet or damp, wear rapidly away under the weight and pressure of heavy carriages. The hardest limestones wear away very quickly when wet, and all stones of an aluminous character, and also gravel that consists of flint, sandstone, or other weak pebbles.

The great advantage of having a road perfectly exposed to the action of the sun and wind will be more accurately conceived by referring to writers of science on evaporation. Dr. Halley states that one-tenth of an inch of the surface of the sea is raised per diem in vapour. He also says, that the winds lick up the water somewhat faster than it exhales by the heat of the sun;—other writers say that the dissipation of moisture is much accelerated by the agency of sweeping winds, the effects being sometimes augmented five to ten times.

Besides the benefit which a road receives from drying rapidly by an open exposure to the atmosphere, there is another of great importance—namely, that of affording to horses the advantage of free respiration; for it is well known that the powers of

a horse to perform work with ease, particularly when moving rapidly, depends upon the quantity of cool and fresh air that he can pass through his lungs; and therefore it is particularly important to have a road so circumstanced that a horse may, in all parts of it, have the benefit of a free current of air.

It may sometimes be proper to make a road deviate from a straight line in order to go through a town; but the expediency of such a deviation must wholly depend on the general object of the road. If it be intended to expedite the communication between two places of great trade, or otherwise of great importance, then nothing can be more erroneous than allowing the general line of road to be taken from the best and shortest direction in order to pass through a town. It is for this reason that little attention should be paid to the opposition of inhabitants of towns to new roads, when to be made for the advantage of the general communication of distant and important parts of the kingdom.

Some persons may be disposed to say that a road should be made to deviate from a direct line, in order to avoid crossing parks or demesnes, and, to a certain extent, no doubt it should; but this motive ought not to be allowed to have much weight, where the consequence is to force the road over an inconvenient ascent, or to add very materially to its length.

The art of road-making, like every other art, must essentially depend for its being successfully conducted, on its being exercised in conformity with certain general principles; and the justness of these principles should be rendered so clear and self-evident as not to admit of any controversy.

A knowledge of true principles is indispensably necessary in every art, and in that of making roads as much as any other. Some preliminary species of knowledge is very necessary in every superintendant or surveyor.

One of the most important and most obviously correct of these principles, is that which requires a road to be made of such a degree of substance as shall be in a due proportion to the weight and number of the carriages that are to travel over it.

Now, although this is in appearance a self-evident proposition, in practice no rule is so universally violated.

It may be laid down as a general rule, that on every main road where numerous heavy waggons, and heavy loaded stage coaches are constantly travelling, the proper degree of strength which such a road ought to have, cannot be obtained except by forming a regular foundation constructed with large stones, set as a rough pavement, with a coating of at least six inches of broken stone of the hardest kind,

laid upon it; and further, that in all cases where the sub-soil is elastic, it is necessary, before the foundation is laid on, that this elastic sub-soil should be rendered non-elastic by every sort of contrivance; such, amongst others, for instance, as perfect drainage, and laying a high embankment of earth upon the elastic soil to compress it.

When stones are very hard, they never make a smooth surface. Limestone will make a much smoother surface than whinstone and other harder stones, but they should not for this reason be preferred to harder stones; for these will wear longest, carriages will run lighter over them, and the expense for scraping and repairing will be less. All the soft kinds of stones make heavy roads in wet weather, and in dry weather there will be some friction upon roads made with them, because there will be more dust on their surface.

If the plan here laid down for constructing a road be faithfully executed, it will secure all the objects that can be required. From the moment it is first opened it becomes daily harder and smoother, and very soon consolidates into as hard a mass as can be obtained by the use of broken stones.

A useful road may be constructed by making a foundation with rubble stones, and laying broken stones or gravel upon them.

The stones should be reduced so as not to have any of them more than four pounds in weight. These should be laid in a regular bed to the depth of seven inches in the middle, and four inches at the sides, supposing the road to be thirty feet in breadth. A coating of small broken stones should then be laid on in an even and regular manner.

If the subsoil be clay, a course of earth of any kind that is not clay, of the thickness of six inches, should be laid upon the clay to prevent it from rising and mixing with the stones.

A road made according to the rules here given will not be a very expensive one, and will answer for use where the traffic is not very heavy.

A road may be constructed suitable to light traffic by forming a level bed in the natural soil, and putting upon it a body of broken stones of twelve inches in thickness in the middle, and six inches at the sides. The stones should be laid on in successive layers, taking care to let each layer be worked in and consolidated before a fresh one be laid on. If the subsoil be clay, a course of earth should be laid upon it, as proposed in the last plan.

In a country where no stone can be got for making a road, and nothing better than gravel can be procured, the following plan of employing it may be adopted:—When the bed of the road has been

formed, a coating of small gravel should be laid on, four inches thick, over the whole breadth of the road. Carriages should then be let run upon it, and the ruts should be raked in as soon as they appear.

When the first coat of gravel has become tolerably firm, another coating well screened, should be laid on, three inches thick over the whole surface, and the ruts raked in as before.

When this second coat of gravel is consolidated, a third should be laid on three inches thick; this coat of gravel should be well riddled, and cleansed from all earth or clay; and all pebbles exceeding one inch and a-half in diameter should be broken before they are laid on the road.

This process should be repeated until there is a body of gravel laid on the road sixteen inches thick in the middle and ten at the sides, so as to form a convex surface, rising six inches from the sides to the centre. The strongest and best part of the gravel should be put on the middle fifteen feet of the road, and the small part of the gravel on the sides.

In all gravel roads of the above description the greatest care must be taken to drain the subsoil by a sufficient number of cross and mitre drains, communicating with the main drains, and if this is not attended to it it will be impossible to form a good carriage way.

A road made with gravel in the way here recommended, will be much stronger than gravel roads usually are; but it will be much inferior to one made with stone materials. The roundness of the gravel stones prevents them from becoming consolidated by pressure, so as to form a perfectly hard road surface; and when the gravel consists of limestone, flint, freestone, sandstone, or other kinds of weak stone, it is so rapidly pulverised that the friction produced by wheels passing over it, adds greatly to the labour or power requisite for draught.

Friction has a very great influence in checking the motion of a carriage, therefore any means by which it can be reduced, conduces much to the economy of the power employed in drawing the carriage; consequently that material which becomes soonest consolidated into an even surface, provided it possesses the other requirements for making a good road material, is best adapted for this purpose, and is much to be preferred to round or gravelly materials for road making.

A road, however much neglected and out of repair, will have generally, at a certain depth, a hard bottom; above this will be a coat of mud, dust, or other loose stuff, more or less deep, according to the material used, the frequency of repair, or the quantity of wet to which it may be exposed. A wheel even mode-

rately loaded will force its way through, and form a rut in this upper coating, sinking until it reaches the hard bottom; and it is evident therefore that a hard material and constant and judicious attention are needed to keep the roads in good working order, and free from requiring the great and expensive repair which must inevitably accompany the above described state of a road.

In few cases does the old proverb "a stitch in time," &c., apply more forcibly than in the management of roads: a small amount of care and attention, and a cartload of stones applied at the right time, and in the right place, will often, nay, always, prevent a more serious outlay; and such facts cannot be too constantly remembered and acted on, by those in whose hands such charges are reposed, more particularly in our rural districts, where the principles, as laid down by M'Adam, are so constantly and perseveringly set at nought.

# CANALS.

THE origin of canals, and their first employment, are very uncertain, but they were evidently known and used in China at a very early date; but since the acquaintance of Europeans with that country, no improvement has been made in their construction.

They are known to have been in use in Egypt long before the invasion of Britain by the Gauls; and the first canal made in Europe, as far as we know, was that cut by Xerxes across the low isthmus of Athos.

In modern times they were first used by the inhabitants of the Netherlands, in consequence of the extreme flatness of their country, and the numerous channels of water which intersect it in all directions, in connection with the lower branches of the Rhine and other rivers.

In Holland and Belgium, therefore, canals in a great measure exist as an essential requisite in the general arrangements of the country, and are, in

point of fact, so many wet ditches or drains to receive the superfluous waters.

The utility and extension of canals, however, as a means of interior communication, would be restricted to particular places until the invention of locks, by which they could be extended into the interior of countries of considerable elevation above the sea. It is somewhat doubtful when this contrivance was first adopted; but it is certain that locks were constructed upon the Milan Canal, about the end of the fifteenth century.

Some controversy has arisen in regard to the country in which they were first adopted. Belidor, in his "Architecture Hydraulique," attributes their invention to the Dutch, but it is probable that the contrivance to which he refers was a sea-gate, and had little resemblance to what are now understood by locks. The invention has also been claimed for the Venetians; and it is stated that Leonardo da Vinci, the painter, applied locks in 1497 in the Milanese canals.

It is said that the first lock constructed in England was employed on the river Exe, in Devonshire, and was made in 1675 to assist in improving the navigation of that river.

In the "History of the Chinese Empire" by a Mongol historian, named Rashid-ud-Deen, written by

him A.D. 1307, there is the following curious notice of the manner in which the Chinese navigate their canals without the assistance of locks, and it runs as follows:—"When the ships arrive at the sluices, they are raised up, whatever be their size, by means of machines, and they are then let down on the other side into the water." This is an exact description of the practice at the present day, as may be seen on referring to the accounts of the English embassies to that country.

The sluices which maintain the water in their canals at the necessary elevation or level, are of the rudest construction: buttresses formed of blocks of stone, with grooves in them, fitted with thick planks, are the only locks in use, even in the Imperial canal.

The earliest attempt to make canals in England seems to have been that of trying to form the Sankey Brook into a navigable canal, from the river Mersey to St. Helens, in Lancashire, in the year 1755; and since that period they have been extended into almost every quarter of the island.

Such was the rapidity of their extension in England that between the years 1760 and 1803, no less than 2295 miles of canal were opened. Artificial canals, however, had long been in use on the Continent. In France, for example, the canal of Briare was

begun in 1605, and completed in 1642. Thus, whilst other countries were fully alive to their advantages, the only sign at all resembling an appreciation of their advantages in this country were the attempts to improve the navigation of the rivers. It seems that their ideas of the principles to be carried out for this purpose were the deepening, straightening, and embanking the rivers where necessary, and penning up or lowering the surface of the water by means of sluices and weirs, so as to have the power of producing "flashes," and overcoming the obstructions to navigation.

It has been found by long experience that navigations of this description are liable to perpetual deterioration from the alterations produced in the river by such artificial works, which, instead of remedying the evils they were designed for, have frequently augmented them, and at the same time obstructed the drainage of the country. The circuitous course, and the labour of hauling against the stream, were found to be at all times laborious and dilatory; and these and other difficulties soon showed the desirability of leaving the river, and led to the formation of separate cuts with the pound locks, and the various contrivances since invented to supersede their use. Until the invention of the lock, therefore, very little could be done in the way of inland navi-

gation, except in level countries, such as the fens, when connected with drainage.

Canals formed for navigation are generally upon a dead level from lock to lock. The simplest mode of forming a canal over level ground, is to make it partly by excavation and partly by embankment; that is to proportion the depth of digging, so that the stuff thrown out shall just embank or raise the sides sufficiently to make the canal of the required dimensions. But if the surface of the ground is undulating, or on a declivity, the case becomes more complicated: in conducting a canal across a hilly and rugged country, there are many difficulties to be overcome, much levelling, and many works of art to be excuted. Some of these cannot be foreseen until the operations have been commenced or are far advanced.

The Bridgewater canal may be considered as the first canal ever made in this country—that is to say, an artificial stream crossing hill and valley. The original design of the first portion of this canal, was for conveying coals from the duke's mines at Worsley to Manchester, a distance of about seven miles; but when the canal had reached the road from Warrington to that town, it was resolved to vary the line by crossing the river Irwell at Banton Bridge, and proceed to Manchester up the south

side of that river, with a branch to Longford Bridge. In 1795 an extension was made from Worsley Mill to the town of Leigh, in Lancashire, with a branch to Chatmoss. The branches of this canal in the collieries under ground are together said to exceed eighteen miles in length.

The greatest difference of elevation on any canal in Great Britain, with which I am acquainted, is that of the Glamorgan canal, twenty-five miles in length, with a rise of 611 feet. The next is the Rochdale canal, 31½ miles long, with 78 locks, and a rise of 533⅔ feet.

Some of the canals in Great Britain are very incommodious, from the smallness of the locks, which limit the size of the barges employed; and a far more serious inconvenience in others is the miserably cramped state of the bridges and tunnels, which last are so low and narrow, as to leave neither room for a towing path, nor yet for the boatmen, except lying prostrate, and running the boat slowly along, by pawing against the walls or roof with their hands and feet. Some excuse might be pleaded for those of this sort which were first made, or which are in obscure districts; but it is remarkable that the tunnel of the Regent's Canal, which passes under a portion of the great metropolis, and was only made in 1819, should have no towing path!

In Ireland, as in England, the first attempt was to improve the river navigation, and the first Act of Parliament for Ireland was passed in 1703, for enabling the Shannon to be made navigable. Nothing, however, was done; but the sum of £140,000 was uselessly expended on the Shannon and Boyne in the year 1758, and various other large sums have been wasted and uselessly frittered away in partial improvements of these and various other rivers in this country.

In Scotland, however, the progress of inland navigation has been proportionably more successful, and under the auspices of Watt, Machell, Manton, and Telford in the earlier attempts at its introduction, the system was established on a sound basis. The Forth and Clyde canal, however, has proved a poor commercial speculation; and the Caledonian canal, opened in 1822, after an expenditure, up to that time, of £800,000, has never been much used, and is now abandoned by Government to a private company.

Canals, ever since their adoption, may be said to have undergone little or no change: some trivial improvements may have been effected in the manner of passing boats from one level to another, and light boats have been applied for the conveyance of passengers; but beyond this, they have in their general

economy remained stationary. Their nature almost prohibits the application of mechanism to advantage in obtaining speed upon them, and they have not, therefore, partaken of the benefits which other arts have derived from mechanical science.

## RAILROADS.

It is very difficult to trace the precise date of the introduction of railways into Great Britain. Down to the year 1600, the only method of taking the coal from the pits at Newcastle to the shipping places, appears to have been by carts on the ordinary roads, and, in some instances, by "panniers" on horseback.

In a work published at Newcastle in the year 1649, by a Mr. Gray, called "A Chorographia"—a survey of Newcastle-on-Tyne—it is stated that "Master Beaumont, a gentleman of great ingenuity and rare parts, adventured into our mines with his £30,000, who brought with him many rare engines not known then in those parts—as the art to boore with iron roddes; to try the deepnesse and thicknesse of the coale; rare engines to draw water out of the pits; waggons with one horse to carry down coales from the pits to the staythes in the river, &c. Within a few years he consumed all his money, and rode home upon his light horse."

Mr. Wood says: "Considering that the carts

employed in conveying the coals were in 1602 called "waynes," and the carriages introduced by Master Beaumont, "waggons," and also that ever since that period the carriages employed upon railroads have been designated by the latter name, we may infer that the "waggon" of Mr. Beaumont was applied upon a railway, and that he was the first to introduce them into the North."

If Mr. Wood is correct, the introduction of railways, as a substitute for common roads, into Newcastle, would be between the years 1602 and 1649.

The earliest railway of which there is any account was one constructed near Newcastle-upon-Tyne. In Roger North's Life of Lord Keeper North, he says, that at this place, in 1676, the coals were conveyed from the mines to the banks of the river "by laying rails of timber exactly straight and parallel, and bulky carts were made with four rollers fitting these rails, whereby the carriage was made so easy that one horse could draw four or five chaldrons of coal."

One hundred years after this, or about the year 1776, Mr. Curr constructed an iron railroad at the Sheffield colliery. The rails were supported by wooden sleepers, to which they were nailed.

Mr. Robert Stevenson, of Edinburgh, states that the first cast-iron rails were made at Colebrooke Dale, in Shropshire, in the year 1767.

In 1797, stone sleepers were used by Mr. Barns on the railroad leading from the Lawson Main Colliery to the Tyne, near Newcastle; and in 1800, Mr. Outram made use of them in a railroad at Little Eaton, in Derbyshire.

Twenty-five years after this, iron rails and stone sleepers were employed in the Stockton and Darlington Railway, which was completed in 1825, with the greatest success; and from that period a new era began in the history of inland transportation.

A very amusing "idea," however, seems to have held the early practisers of steam conveyance on railways in such complete subjection, as to have prevented their putting its correctness to the test; and the easy means by which this "unconquerable bugbear" of the early locomotive engineers could have been at once and for ever set aside, is a startling and convincing proof of the absurdity and folly of taking everything for granted without an attempt at proving whether it is correct or not.

They one and all assumed that a carriage or engine moved by steam power could not move along a smooth rail without the aid of toothed wheels and racks, or some other equivalent contrivance; and to overcome this ridiculous and imaginary difficulty, no small amount of expense and labour were uselessly incurred; and it was not until the year 1815, or

thereabout—although Trevithic had worked a locomotive on this principle, as early as 1804–5, most easily and successfully,—that it was proved, by repeated experiments, that the adhesive power of the wheels on the rails was at all times sufficient to cause a progressive motion in an engine with a train of loaded carriages upon a moderately level railway; but although this was proved so as to prevent its practicability being questioned, fifteen years elapsed before steam locomotives, in the present acceptance of the term, were established.

From this period railways seem to have been in a very quiet unprogressive state, and with their wonderful powers and advantages, to have continued in a dormant condition; but in the year 1820, one Thomas Gray—whose far-reaching anticipations shadowed forth the path which others have since trodden; where they have realised profits, achieved fame, and by means of which an inestimable boon has been conferred on the nation and the world—published a work in which he propounded a "General Iron Railway, or Land Steam Conveyance, to supersede the necessity of horses in all public vehicles;" and he maintained its vast superiority in every respect over all the present pitiful methods of conveyance by turnpike roads, canals, and coasting traders."

So great was the merit of this work, that despite the opposition which attended any innovation on the coaching system, it ultimately passed through five editions. After proposing that his plan should be first attempted between the towns of Manchester and Liverpool, he thus described the beneficial results:

"The convenience and economy in the transport of goods bought by merchants at the various markets, and the despatch in forwarding bales and packages to the outports, cannot fail to strike the merchant and manufacturer as points of the first importance. Nothing, for example, would be so likely to raise the ports of Hull, Liverpool, and Bristol, to an unprecedented pitch of prosperity, as the establishment of railways to these ports, thereby rendering the communication from the east to the west seas, and all intermediate places, rapid, cheap, and effectual. No animal strength will be able to give that uniform and regular acceleration to our commercial intercourse which may be accomplished by railways. However great the animal speed, there cannot be a doubt that it would be considerably surpassed by mail steam carriages, and that the expense would be infinitely less."

He proceeded to Manchester, and laid his scheme before the capitalists of that city; but the men who had passed their lives among the marvels of ma-

chinery, and owed their fortunes to steam, could not appreciate the project! They listened graciously; and, with a smile somewhat akin to pity, dismissed him as an incorrigible visionary. Still Thomas Gray persevered; his mind was absorbed in the anticipation of the great and beneficial changes which his scheme would produce. He talked of enormous fortunes realised; of coaches annihilated; of one great general system of iron roads—he was laughed at, but not laughed down. He continued to talk, to memorialise, and to fill the pages of magazines till the public mind was "wearied and worried;" and doubtless not a few wished that railways were established, if it were only that they might be freed from his unceasing importunities.

He petitioned Government, the Board of Agriculture, and even the Lord Mayor and Corporation; and in 1827 Mr. Hume presented a petition from him to the House of Commons. The only result of these and other efforts was that many thought him a knave, and others who were "charitably" inclined, pronounced him a simpleton.

A few years passed away, and the idea supposed to be born of a disordered imagination, became a great reality, and Thomas Gray found his reward—only in himself! In rememberance of his protracted efforts, and the invaluable blessings which they had

materially tended to confer on society, an attempt was subsequently made to give him some pecuniary acknowledgment of "national gratitude," but it was unsuccessful!

Few men in modern times have served their generation more effectually, and yet received so little compensation in the way of thanks or emolument, as Thomas Gray. *He died steeped to the lips in poverty*—a victim to "national gratitude!"

Had he been a "clever lawyer," a successful introducer of some plan by which a particular *clique* had obtained some pecuniary advantage, a high class valet, or even a successful swindler, the events of the last fifteen years will show what would have been his reward.

In an article on Thomas Gray—the railway prophet—published in the *Railway Monthly Magazine*, for April, 1847, are the following remarks, which I make no apology for transcribing:—"Gray's case is another melancholy exemplification of the old truism, that a prophet is not honoured in his own country. There are no reasons, nevertheless, why his name should not go down among the distinguished, although his merit was only one of foresight, for Gray will not be forgotten as predicter of the results of a mighty instrumentality whose giant strength in his day was germinating. Gifted with

a prescience that spoke of prodigies, and of the splendour of a new dispensation, he deserves our admiration and our reverence, and the award that awaits upon suggestive merit.

"Gray, no doubt, drew his ideas from the infantine condition of the system then cradled in the barbarian tramroads of Newcastle-upon-Tyne. Amplifying upon these, and looking through the dark arch of the future, he prophesied for the system a luminous career, tracing, admittedly with a marvellous minuteness, its moral, mercantile, and social effects, as developed at the five-and-twentieth year of its era. They were truly bold emanations, at a time, too, when bigotry fought hard to retard and extinguish any attempts to establish the new dispensation.

"Gray's friend, Mr. Thomas Wilson, thus writes of him:—'In 1816, a project then in contemplation by the late King of the Netherlands, for making a canal from Charleroi, so as to connect and supply Holland with coal from the mining districts of Belgium, was the subject of public discussion. Gray, then resident in Brussels, at once took his stand for a railway, the superior advantages of which he enlarged upon. From that time he devoted the whole energies of his mind to study and master all the complications of a general principle or system of railway. Although he supported his opinions in

favour of railways at that period with a warmth approaching to vehemence of manner, and which acquired him the reputation of eccentricity, he had not apparently any clear and definite notions about a practical system of general conveyance. But he was satisfied theoretically, and upon general principles, of the practibility of such a system, and he set himself in right earnest to work out the problem.

"Shortly afterwards I left, and was absent from Brussels for three years. On my return in 1818, I inquired after my old acquaintance. He had removed to a small house at Etterbech, near Brussels, of which his brother and family occupied one portion; it was clear that fortune had not improved with him. The upper floor of the house was occupied by my friend, the railway system projector, whose devotion to certain dominant ideas, the railway above all, had procured him amongst his few acquaintances the *sobriquet* of the "Original." His apartment, however, was a sealed book, a tabooed place where none were suffered to enter. I was then made acquainted with the fact by his brother, that he had some mysterious work in hand, which could not be named. He himself subsequently informed me that he was upon the very verge of completing his labours, but until that completion he would not give one word of explanation or information, more than that

in their result they would revolutionise the whole face of the material world and of society."

Subsequently, Mr. Wilson adds, that the result of this mysterious seclusion, was Gray's celebrated "Observations on a Railroad for the whole of Europe."

"The project was so astounding, and at the moment appeared to me so chimerical, that I could not help the exclamation—"The poor man is insane!" Yet we live to see it already carried out to an immense extent; and within five years more, supposing one-half only of the projected lines be executed, we shall have one almost uninterrupted line of railway communication from the pillars of Hercules to the banks of the Moskwa. Mocked as a visionary when he first produced his glorious scheme, perfect in almost all its parts as it was, and stands yet, or pitied as the dupe of an ardent imagination, his ardour was not damped. In despite of all his discouragements subsequently, his neglected or unanswered memorials expository of his plans, and soliciting their examination and adoption, to British Ministers of State, to Boards of Trade and Agriculture, to Corporations of London and Liverpool, to public men and capitalists throughout the empire, and the continuous rebuffs, or contemptuous incredulity with which everywhere almost treated, his

perseverance was not the less abated and unrepressed.

"Gray prosecuted his plans in another way. There was not a peer, or a member of Parliament, a Minister of state, or a department, a public body or corporation, directly or indirectly conceived to be interested; scarcely a capitalist, merchant, or manufacturer of note, whom then, and previously, and for years subsequently, Gray did not perseveringly, almost pertinaciously, serve with his petitions, memorials, and expositions in support of the great scheme he had developed. To this very moment he has not ceased to obtrude his counsels upon, to renew his representations to, more than one public department. All the while he was laying the foundations, and gradually raising the superstructure, of which other architects, more astute but far less ingenious, self-denying, and self-devoted, were not slow to reap the credit and the profit."

Mr. Wilson further on, says—"That when Gray first exposed his great scheme to the public view, people were disposed to treat it as the effusion of insanity. But such were his imperturbable convictions, such his enthusiastic impregnation with his grand idea, that I recollect in 1820 he entered my room one day, precipitately, saying—'I have gained my cause; travelling will be performed by steam. Now

I can reply—now people will wish to read—they will read and be convinced!' I asked what had happened? 'The best thing in the world,' said he, 'the *Edinburgh Review* says I am mad, and that I deserve to be shut up in Bedlam.' If Thomas Gray was mad in 1820, how many hundreds of thousands of madmen must there be, in England alone, in 1845?

"Gray is now resident in his native place. He is still writing upon railroads, although he can no longer afford to publish. The author, inventor, of the railway system is actually condemned to waste his invaluable capacity, his energies, and information on the uncertain and scarcely compatible occupation of dealing in glass on commission, and trading with glaziers!

"Five-and-twenty years have passed away, and Gray is comparatively penniless, while those for whom he laboured and predicted are prince-like in their opulence, and their sympathies must indeed be suffering from a sort of Polar spell, if they cannot open their purse-strings to the appeal now making for the 'railway prophet.'"

It has been shown further back that this appeal was unsuccessful, and that "he died steeped to the lips in poverty," a victim to "national gratitude,"—a commodity of which this nation has, within the last hundred years, shown strong symptoms of possess-

ing rather too bountiful a supply; or if not exactly that, at least a wrong way of applying it.

By the year 1826, the Manchester men had evidently found the truth of Gray's remarks, and had begun to comprehend the "madman," as he was frequently termed; for we find that in 1826 the Liverpool and Manchester Railway Bill was carried through Parliament, after the line had been surveyed, under Messrs. George and John Rennie, by Mr. Charles Vignolles; and in comparison with the "recent practice" of railway making, it may be mentioned that the line was estimated to cost £796,246, and was opened in 1830, having cost £739,165—a sufficient proof of the capability of the Messrs. Rennie for making a correct estimate.

The success of this railway, and the then wonderful speed attained upon it by the locomotive of the Stephensons, gave such an impulse to railway making that everybody's attention was turned to this subject; and for the last twenty-five years railway making has given rise to such conduct and revelations as have caused the honour and integrity of Englishmen to appear in a light anything but favourable, and which it will take years to restore, if it be possible, to their ancient honourable position.

The commercial code of 1845 was, as far as railways were concerned, framed upon anything but

moral principles. The lust of gain blinded the eyes of men, who before that period could see clearly enough the difference between right and wrong, between trading and gambling, and between legitimate and illegitimate speculation. Men who would have scorned to do a dishonest act towards any other real tangible living man, did not scruple to do acts towards that great abstraction, the public, which no morality could justify. In the height of the railway mania it was generally admitted that ultimately *some* parties must be losers; that the over-sanguine or the cautious, who came in last would have to pay the piper for all the gains made by those who came in early; but as nobody knew who these individuals were, nobody cared about them, or scrupled to make an immoral profit out of them.

Unfortunately the close of this mania did not abolish the system, for it is still as vigorous as ever where opportunity offers, and this fact has been recently exhibited in a very flagrant manner in one of the greatest undertakings of late years. It is a vice that seems to be in a fair way of becoming an utter plague in the land—a pestilence destructive of honour, honesty, and everything which it should be the boast of a country to possess.

In 1838 the line from London to Birmingham was opened; and these were followed by the Grand

Junction, the Midland, North Midland, Great Northern, Great Western, &c.; and at the beginning of 1840 the number of lines in the United Kingdom, actually begun or finished, amounted to fifty; since which time they have rapidly increased and are still progressing.

It must be remarked, however, that it should be, and is necessary, before the expenditure of capital in the construction of a line of railway can be justified, that some more precise estimate of its merits should be possessed, than can be afforded by a vague conception of eligibility.

It is necessary to see, not only that it will realise profit, but that it will pay a dividend large enough to warrant the prosecution of the undertaking; and this conclusion can only be arrived at after a careful investigation of the extent of the traffic, and of the existing rate of charges, and by the discovery of the relation which the return thus deduced has to the cost of construction.

Let us take as an example of the effects of the opposite course, the Great Western Railway, which with its splendid bridges, viaducts, and other works of art, and its magnificent terminus at Paddington is grand and imposing to contemplate, as showing what capital can accomplish: but, unfortunately for the original shareholders, "it does not pay;" and the

shares are now quoted at 30 per cent. discount, showing that nearly one-third of the capital has been spent unprofitably (wasted ?), and therefore never ought to have been expended at all. However, we must say that it is only *é pluribus unum,* numerous cases of a like nature being easily obtainable, and that unfortunately with little trouble.

In constructing a railroad, an immense amount of outlay is incurred before a single object can be transported. Extensive lines of road, attended by works of art of prodigious magnitude and cost, are formed. Large buildings are provided for stations; and, in fine, a stock of engines and carriages is fabricated. All these expenses are incurred preparatory to locomotion, and must be divided among the quantity of transport executed. Indeed, the mere labour or expenditure of mechanical power necessary to transport the objects of traffic from point to point along the road, forms the most insignificant item of the entire cost; and this item alone is in the direct proportion of the quantity of transport. The proportionate cost of railways, in round numbers, taking the United States as 1, is: Germany, 2; France, 3; England, 4.

This great difference does not arise from the greater value of land in England, but from our defective system of railway legislation. The cost of

obtaining an Act of Parliament, and the enormous law expenses consequent upon opposition from land owners and rival companies, form a large item in the cost of British railways, from which foreign lines are comparatively free.

Few of the branch lines in England pay remunerative interest upon the capital expended. Branch lines are generally made by the company that constructed the trunk line; or, if made by an independent company, are either bought up by the company of the trunk line, or an interest is guaranteed upon its cost of construction, so that the greater part of the branch lines in England, instead of proving "*feeders*" to the trunk lines, and increasing the profits, are "*suckers*," and tend to diminish them; and the average interest on the capital expended *has not been more than* 2 *per cent.*

In addition to the excessive cost of railways, another chief cause of the low interest paid to the shareholders, is the reckless and highly reprehensible manner in which opposition trunk lines and unprofitable branches have been constructed; and there is evidently something defective in the legislation of a country in which, though swarming with legal men, whose number is daily increasing, no undertaking of recognised utility can be carried on without entailing enormous costs to the promoters

for obtaining permission to do so, and without necessitating buying off opponents, or defending its interests against rival companies or obstinate landowners.

It would also appear that some check is required upon the conduct of those entrusted with the management of these affairs after they have been started. This is only too evident in dozens of cases within the last ten years; and in no case is this want more apparent, than that of the modern "Noah's Ark," which might have been an honour to the country instead of a bye-word, a ridicule, and a disgrace—a position it now occupies, not from any defect in itself, but solely from the incompetence, presumption, and jobbery of those from whom something rather different should have emanated. Should another flood arise, I wonder how many of the "powers that be, and were," would be worthy a place in her?

All the trunk lines being now constructed, and many hundred miles of unprofitable branches, there still remain many large districts *totally unprovided* with railway accommodation. There are many large agricultural districts, and numerous small towns and villages, which are ten to twenty miles from any railway station; and it is pretty evident that these must labour under great disadvantages when compared with those near the railway.

A landowner who lives twenty miles from a railway must pay at least 10*s*. per ton for all goods transported to and from the railway, and consequently he cannot compete advantageously with the other landowners more favourably situated; and thus a railway does not supply all the requirements of populous districts.

The railway system, as it stands at present, is limited, exceptional, and incomplete. No system can be considered complete, which does not possess the means of drawing produce, and carrying traffic into, and out of, every town, village, hamlet, and homestead within its reach.

Simple as is the idea of a railway, we see the prodigious expense necessarily incurred in bringing it into practical operation. All inequalities of surface in the ground must be removed; low parts must be filled in by embankments; high parts must be reduced; eminences, which it would be impolitic to level, must be perforated by tunnels, and the whole route brought as nearly as possible to a level.

Besides all this, the land over which it is to proceed must be purchased, frequently at an exorbitant cost; and the preliminary expense of overcoming petty opposition, and procuring an Act of Parliament to establish the line, mentioned as "purchasing

land and compensation," averaged on three lines the outrageous sum of £14,000 per mile!

The waste of capital directly and indirectly in the formation of railways, has been estimated at not less than £12,000,000! apart from the loss which has been incurred in the support of unsuccessful Bills, and the maintenance of unsuccessful opposition. This sum would have been sufficient to construct a railway six hundred miles long, at the rate of £20,000 a mile; while the interest which has to be paid by the public in the increased cost of existing lines amounts, at 5 per cent., to £600,000.

Of the cost of projects which were ultimately unsuccessful, a single illustration may be given. In the celebrated battle of the Stour and Rugby Railway, the enquiry continued during sixty-six sitting days, from February to August, 1839, and having been renewed in the following year, the Bill was finally defeated at an expense to its promoters of £146,000!

To show what advantage the "gentlemen learned in the law" obtained from this state of affairs, it is mentioned that the bill of the solicitor of a certain line leading out of London, contained ten thousand folios, occupied twelve months in taxation before the master, and amounted to the exceedingly modest sum of £240,000!

Another company had to fight so hard for their Bill that they found, when at length they reached the last stage, that of receiving the Royal assent, that their *preliminary* undertakings had cost *nearly half-a-million of money!* and that before a single yard of line had been, or could be constructed.

The cost of this railway mania was enormous. Utterly worthless and fraudulent as were many schemes, they involved as much preliminary expense as if they had been substantially good.

In looking back at the history of the railway mania, we have a remarkable illustration of the great truth that "He that getteth riches and not by right, shall leave them [or they him] in the midst of his days, and in the end shall be a fool." In an age like the present, when integrity and moral worth of character are daily becoming of less value, when there is manifested so strong a tendency to worship gold—which unfortunately is not confined to age, birth, or position—and a man's value is estimated by the reply to "What is he worth?" or, "How much has he got?" rather than for any rectitude of conduct or integrity of character, we may well pause to ponder the lesson, and to give it a personal and practical application.

It has been truly and well remarked in relation to these scandalous proceedings, that "out of a true

spirit of legitimate enterprise arose a mania, in the midst of which many a needy rogue was transmuted into what 'society' calls 'a gentleman.'" It is unnecessary to cite specific instances, though this could easily be done; and the fact is abundantly illustrative of the recklessness so characteristic of the times, and the "morality" of the commercial system of 1845.

It is computed on high authority, that in the aggregate estimated capital, at least one per cent. would be required for the above-mentioned purpose —a sum as much lost as if fifty first-rate line-of-battle ships had been sunk to the bottom as soon as launched—as if two million quarters of wheat had been thrown into the sea—as if a conflagration in the metropolis had consumed 10,000 average-sized houses.

The item of advertisements alone will serve as an illustration. "We will answer for it," said a competent writer, "that during the two or three months immediately preceding the late salutary check, as much as a hundred thousand pounds a week were spent in railroad advertisements!" This statement was made on November 8, 1845, and the advertising still continued.

For an admirable and telling "show up" of the way in which railway "cookery" was carried on,

and if the reader wishes to understand their general working and tendency, I would refer him to a clever and ably written little work, No. 89 of the "Traveller's Library," published in 1855, entitled "Railway Morals and Railway Policy."

That the "worship of gold" is not confined to any position in society, was well exemplified in the case of the Yorkshire "tape-measurer," whose favour and dinners were courted by the highest and noblest in the land, and of whose acquaintance peers and peeresses were proud.

That "love of gold" is in the same position the following will show. A "noble lord" had an estate near a proposed line of railway, and on this estate was a beautiful mansion. Naturally averse to the desecration of his home and its neighbourhood, he gave his most uncompromising opposition to the Bill, and found in the committees of both Houses sympathising listeners. Little did it aid the projectors that they urged that the line did not pass within six miles of that princely domain; that the high road was much closer to his dwelling; and that as the spot nearest to the house would be passed by means of a tunnel, no unsightliness would arise. But no; no worldly consideration affected the decision of the projector; and, arguments failing, it was found that an appeal must be made to other means. His op-

position was ultimately bought off for twenty-eight thousand pounds, to be paid when the railway reached his neighbourhood. Time wore on, funds became scarce, and the company found that it would be best to stop short at a particular portion of their line, long before they reached the estate of the noble lord who had so violently opposed the Bill, and whose aid they felt themselves sure of obtaining for their second Bill, by which they sought to be released from the obligation of constructing the line which had been so obnoxious to him. What was their surprise at finding this very man their chief opponent; and then fresh means had to be adopted of silencing his objections!

The following remarks on the present state of our railroads are extracted from a small pamphlet, entitled, "Railway Management, or How to Pay Ten per Cent.," which, in addition to these, contains some gross mechanical blunders, which, however, may be overlooked, as they show that mechanical knowledge has not been the author's pursuit, though he is evidently well-up in the other branches of railway matters, and gives some good and sensible hints on the subject on which he treats.

The stock invested in British railways, amounts to upwards of three hundred millions sterling! It is impossible to estimate the number of persons who

are the owners of this vast capital, but there can be no populous district which does not contain numerous proprietors.

It is generally admitted that, regarded as an investment, railway property has hitherto proved a failure. Either railways have been grossly mismanaged, or they are incapable of yielding the return which was universally expected when the mania for railway enterprise was at its height. Many are of opinion that this failure is mainly due to mismanagement, and that in spite of the enormous waste which has irrevocably taken place, in exorbitant compensation charges, legal and parliamentary expenses, insane competition, &c., railways in general might yet be made to yield remunerative dividends.

The conduct of these concerns has been pretty exclusively in the hands of persons of the following description :—

(A) Lawyers and gentlemen at large, open to be employed as secretaries, general and traffic managers, &c., at handsome salaries.

(B) Aristocratic M.P.'s and noblemen willing to figure as promoters of great enterprises, for various political reasons, and whose countenance is always first sought after by projectors of new companies—1st, for the purpose of DRAWING support from the

very large class of toad-eaters, with which our English community abounds; 2nd, because, knowing little of business concerns themselves, they are easily MANAGED by those whom they patronise, in return for their own selection; 3rd, having great social and political influence, they can thus materially assist in MANAGING the distinguished, but more business-like, and therefore more troublesome, directors; 4th, being naturally indolent, they are only too glad to leave the management in general to those officers who can best succeed in "making things pleasant."

(C) A sprinkling of merchants, &c., with more of their own business to attend to than they can easily get through, but who nevertheless serve as GUARANTEES to the public that everything will be properly carried on, whilst they can be outvoted as often as convenient by the managers' majority.

(D) Engineers who have individually a reputation to acquire or maintain from great works, and a fortune to make from such reputation ere they condescend to consider the paltry savings of a parcel of shareholders, too often regarded with contempt. These latter gentlemen get the lion's share of the profit; for unless the engineer's salary is computed from the amount expended on the works, he usually receives a commission on such expenditure; and

whilst thus paid sufficient to satisfy most reasonable men for their whole time, they frequently serve two or more companies at once, besides attending to other professional business. So, also, have they usually a considerable voice in the management. For does an intelligent and honest secretary, considering his constituents at large, pass over improvements in locomotion, economy in management, or new expedients for traffic, there will inevitably be a misunderstanding between himself and the high-minded and experienced engineer, resulting in the annoyance of MY LORD, whose supporters will swamp the men of business; and if such unpleasant questions occur too often, the troublesome official will be sure to go to the wall. Our engineer has too much knowledge, and is far too practical to listen to new-fangled theories of any kind. His ideas are formed on a great scale; any amount of expense is a "flea-bite," whilst his own establishing or established reputation is everything; and woe be to the subordinate assistant or mechanic who dares to suggest novel expedients, or to make himself too useful, whilst within reach of his superior's awful and comprehensive shadow.

Here, then, is a select community made up of individuals the most of all calculated to resist advance, and to avoid unnecessary responsibility, so as

for ever to run on in grooves, whilst they continually promote expenditure by their failures: the idle man of weight, who does nothing he is not obliged to do; the knowing official, who must please his "directors" at all hazards; the already overburdened, too glad to have others on whose shoulders his own responsibilities may rest; the practical self-seeker, too wise to connect his name with plans never before heard of, lest failure should swamp his reputation, but always ready to fill his pockets in any and every acknowledged professional manner.

In such a direction, what brain work can be expected, beyond following the established lead?—and what management shall be looked for but mismanagement?

When a man of business opens a shop, he is anxious to do all in his power to attract customers. If the neighbours have not been in the habit of using his wares, he endeavours to persuade them that it would be to their advantage to do so. His attentions are not confined to those who know the value of his articles, and are obliged, for their own interest, to seek him out; he does not shut the shutters, or keep a forbidding personage at the door to frighten strangers and prevent their entrance, but decks out the windows and lights them up in the most brilliant manner, so as to invite observation;

and those who best understand the art of money-getting, even place touters outside to add the power of oral persuasion.

Noble lords, and other less aristocratic spirits, may be much disgusted at the idea that a grand railway undertaking should be likened to a SHOP; and it is certain that the principle upon which these vast concerns have been hitherto conducted, has generally been the very reverse of that to which allusion has been made. The principle followed by boards of directors has been that all such arrangements as the fixing of fares, the provision of accommodation, &c., are to be settled upon the plan of screwing as much as possible out of the few who are OBLIGED to use the road, provided always that the opposition of rival lines be discouraged or put down. This, by the way, is the old-fashioned jealousy of rival coach proprietors, being, as it were, perpetuated by the members of the four-in-hand club.

These wiseacres (this descriptive term proves that the shallowness of landed proprietors has long been proverbial) cannot see that with an inexhaustible motive power, it is their interest to carry as many as could be enticed abroad, who, from the amusement that might be thus afforded them at a cheap rate, would acquire the habit of spending money in that way. So, from the fear that the rich, and the

traveller on business, might get somewhat too much for their money were fares low, some 20,000,000 of stay-at-home people are rather encouraged to continue to stay at home than to enjoy what ought to be the pleasure of travelling.

Upon this principle, also, when they do venture out, the best customers of railways are rendered as miserable as possible by a sapient directorate, thus indirectly desiring them not to come again. Third, nay, even second class passengers, are herded together like cattle, in cold, hard, comfortless boxes, in which every individual BEAR (the race is numerous) shall have the greatest possible power of annoying more civilised (so that they be not richer) beings than himself. Third classes are even sentenced to imprisonment in these dens for a much longer period than is necessary, and at considerable expense to the proprietors by way of punishment, as it would seem, from the magisterial directors, for daring to have the impertinence to travel at all.

Large collections of such offenders are daily thrust upon sidings that they may be tantalised by the sight of well padded empty carriages whirling along at full speed by the aid of the same power, which, if wisely applied, might be carrying themselves to a warm fireside, which they are inwardly resolving never to leave again, unless compelled to travel,

when they shall have expiated their present folly in coming thither. Once a year, indeed, the great men benignantly condescend to trot out these contemptible poor people on somewhat easier terms as regards time and money (though the less said about comfort the better), provided they allow their lives to be put in imminent jeopardy—as, for instance, the run through at the King's Cross Station a short time since, where an excursion train of thirty-five carriages was provided with *two breaks*, one of which was managed (!) by a drunken guard! Excursion fares are perhaps lower than would be necessary to tempt people every day in the year, could they travel in safety, and be at liberty to choose their own time and opportunity; yet the numbers who rush into excursion trains are so great, that the several extraneous expenses of special advertising, special clerks, police and porters, special engines, guards, drivers, and stokers, special wear and tear in the shape of smashed rolling stock, and special damages for loss of life and limb—all which are rendered more or less inevitable by this insane kind of irregular traffic—are more than counterbalanced by the extra receipts; otherwise one can hardly imagine that it would be continued from year to year.

These special expenses are just so much money thrown away. In like manner is the daily expense

of running separate and special third class trains sheer waste. Divided and attached to the ordinary trains, these passengers would be carried without any additional cost; but in that case, the best, because far the most numerous customers, would not be sufficiently annoyed.

Coal is carried upon railways at one halfpenny per ton per mile, and it has been asserted that at this rate coals pay better than passenger traffic, because the tonnage is so much greater. The rate at which third class passengers are charged, reckoning two cwts. to each, including luggage, is 1*s.* 8*d.* per ton per mile. These pay better than first or second class, for the same reason that coals pay better than either. The number more than makes up for the difference of fare. So also excursions at one-third the parliamentary rate pay better—with all their draw-backs in the shape of extra charges—than ordinary third class trains.

In the face of these facts, there can be little doubt, that were the people able to travel at a fair average speed in comfortable carriages, every day, and at any time of the day, at half the present parliamentary rate, viz., a halfpenny per mile, (*i.e.*, tenpence per ton per mile, or twenty times the coal rate) railway dividends would be enormously increased. The people must and will have amusement of some sort; of all kinds

of recreation none is so seductive to English men, women, and children, as travelling to see the country or visiting their friends; and therefore when it can be done cheaply, with comfort, and without loss of time, there can be no reasonable doubt railways will absorb half, at least, of every shilling now paid for less innocent amusement; producing indeed, a grand social revolution in the country.

Two classes only would be sufficient, a few shillings extra per 100 miles being charged, not for additional comfort or speed, but for exclusiveness.

When the enormous weights now placed on small luggage trucks with four wheels are observed, the number of extra carriages occasionally collected for excursion traffic, and the extent to which this irregular work is able to be carried on; nobody can believe either that the rails are unequal to bear any amount of passenger freight, that sufficient rolling stock cannot be provided, or that fully packed regular trains might not be made to deliver their thousands of passengers daily, in lieu of the present and spasmodic loads, interspersed between the usual string of half empty carriages.

In calculating the relative expense of goods and passenger traffic, it must be remembered that the former require one to load and unload the trucks; also in the case of coal, the trucks must return

empty, whilst passengers employ no labour of this kind, and the carriages are filled in both directions.

It is not between the large towns and the metropolis only, that the influx of traffic would be carried on, but every village might become likened to a beehive, having its inmates continually buzzing to and fro.

At present horses on common roads can beat rail and steam. This is proved by the fact, that numerous loaded vans are during the summer daily driven from Bristol, to the little watering places of Clevedon and Weston (a distance of fourteen to twenty miles), filled with excursionists, because the fares of the Bristol and Exeter Railway, which goes to both towns, are from sixpence to a shilling higher than the rates charged by these horse vans. Is it not a disgrace to the managers of any railway, that shrewd men should invest capital in vans and horses, for the purpose of carrying mere pleasure seekers along the very line of railway, and make it pay? It is evident that if this can be accomplished in one locality, it could in the neighbourhood of almost any line as at present so misconducted.

Railway directors, relying on the passenger traffic of TRAVELLERS, have not only overlooked the more numerous class of pleasure seekers, but have neglected almost altogether a very considerable source

of profit from what may be termed, by way of distinction, HOME passenger traffic. Considering the fact, that the expenses of getting up steam and working a train, are almost precisely the same, whether the carriages be many or few, whether they be full or empty, and therefore that every additional sixpence received is so much clear gain, it is really wonderful that in this practical age the immense resources at the command of railway companies, from a profitable use of the land in their possession, hitherto lying idle, can have so long been unperceived. Incalculable losses have been incurred by the construction of branch lines to unimportant towns, without any effort being made to obtain an increased population, either in these towns and villages, or along the lines themselves. Hundreds of acres belonging to the companies have been turned into mere waste, which, converted into building ground might have been, and might yet be, rendered highly profitable. Granting that there may be companies unwilling, or who have no power to build houses for tenants, merely as such; there is, at any rate, nothing to prevent them from providing cottages for their own servants, who might occupy these houses as part of their wages; and the men might be conveyed by early and late luggage trains to and from the stations at which their ser-

vices are required, without any expense to the company. The effect would be, that every servant would derive a benefit much greater than the difference of wage, which would be saved to the management. They would breathe country air, and be enabled to purchase country produce—each of great value in the maintenance of health and the provision for their families—whilst the shareholders might get full 20 per cent. on the building capital, by the consequent deduction from salaries in lieu of rent.

Irrespective of peopling the companies' own land, the increase of population in the neighbourhood of each station ought to be assiduously encouraged. This might be done to almost any extent by the judicious application of the annual ticket system. The citizen is carried three miles out in an omnibus for sixpence; the railway might carry him thirty miles for the same money, within the same time. Is there any doubt which tens of thousands of sensible men would choose?—when it is considered, moreover, that according to the same proportion, he might go ten miles for twopence, or five for a penny, can any limit be imagined to the number of country-living townsmen that might be produced? A gentleman lately observing a property advertised for sale, enquired the price of an annual railway ticket from London to the nearest station, which was Loudwater,

on the Wycombe Branch of the Great Western—thirty-one miles and-a-half from Paddington. The answer was—thirty-three pounds and one shilling! This price was prohibitory, and the negotiation ended; but the amusement created by this affectation of fairness and accuracy of calculation, amply repaid the trouble consequent on "wanting to know." Thirty-three pounds ONE SHILLING for an annual ticket appeared very much like railway red-tape run mad. Surely the correct proportion might have been stated more nearly in decimals! How, indeed, can any shareholder expect a decent dividend from such finikin fine gentlemen or MISS-management as this?

Some of the metropolitan terminating lines make a much better approach to common sense—*e. g.*, the South-Western and the Brighton, which derive considerable revenue from annual ticket traffic at moderate rates. When they shall have adopted the cheap rate, these will soon become greatly augmented.

Annual tickets for ladies might also be even more remunerative in proportion than for gentlemen, if charged at about a fourth or sixth the rate of the former, because they would probably not be used more than one-tenth as often on the average; nevertheless, they are indispensable to the home passenger

traffic system. It is, however, needless to observe, that no such idea as that of separate provision for ladies has ever entered the heads of railway directors.

Although railway property might be made to pay remunerative dividends by the due development of passenger traffic, all other matters remaining under the present system of management, there are many ways in which the desired result may be materially aided—*e. g.*, economy of power, by improved engineering expedients; prevention of accidents; saving of overcharged rates; economy in expenses of administration.

When traffic shall be encouraged to the fullest extent, accidents prevented, repairs cheapened, rating made equitable, staff management reduced, and the directorate made business-like and vigilant, British railways may fairly be expected to return an average of 10 per cent. upon all the capital invested—a consummation, I fear, not likely to be immediately obtained, however devoutly it may be desired.

# COMPARISON OF ROADS, RAILROADS, AND CANALS.

## ROADS.

THE great advantage in favour of the road system over its two competitors is, that *it is already constructed to most of the points requiring to be opened up;* and they are compact, well made, and in good condition, constructed with easy inclines, and having all the bridges, culverts, and other works of art ready constructed; the chief population and chief villages laying along them.

These works, all of which were constructed by our forefathers, in a solid and substantial manner, at a great expense, and have been brought into good condition by others at a later date, are now comparatively useless. The locomotive and the railway have diverted all the through traffic that formerly passed over them; and the restrictive, if not prohibitory tolls, which are allowed to be imposed on steam engines and carriages, when employed upon

them, have prevented any portion of the traffic being kept on them, and they are now almost deserted.

Such being the fact, it is at once evident that the object of all in any way interested in the question of traffic or sending produce to market, should be to convert these fine ready-made, though useless roads, into branch lines, and make them feeders to our trunk railways; and in order to do this, and work them in an effective manner, a very small outlay is required—one hardly deserving of any consideration, when it is remembered that by using the existing roads, one of the greatest items of cost in the case of railroads is entirely avoided—that land and compensation, the expense of cuttings, embankments, tunnels, bridges, viaducts, and other works of art are not required, consequently the cost of starting such a system is reduced to that of the rolling stock, and the shops for repairs and other appliances necessary for carrying on the traffic.

Another great reason for carrying out this plan is, that since railways have removed so much of the traffic from the roads, the tolls have become almost extinct, or at least reduced to a most insignificant amount; and the interest paid on the amounts advanced for their construction, is as much as can be managed, including the keeping up of the roads in many of the trusts.

If, then, a moderate and fair toll were to be imposed upon steam carriages, traction engines, and trains, and road trustees and others were to assist in their development, instead of continuing to manifest, or at least quietly to acquiesce in, the short-sighted obstructive and foolish policy of bygone years, there can be no doubt that such a traffic would spring into existence in various localities throughout the country where railway accommodation does not exist, as could not fail to make them regret the proceedings of former years, and convert them into staunch supporters of the principle of Steam on Common Roads.

It must be remembered that whatever disadvantages they may possess, turnpike roads allow *every species of carriage to travel upon them, to draw off and on, and cross them at all places*; that the farmer's cart on these roads can take his produce at once to market after being loaded in the field, and that goods can thus be loaded and taken at once to their destination without the damage and loss arising from the transhipment on the railway,—an advantage that is not possessed by the railway.

The relative cost of haulage of goods and merchandise, both by steam and horses, on the rail, the canal, and the road, will be given towards the end of the work, under "Cost of Working;" and I think I

shall have proved, beyond a doubt, that starting *ab initio* to make a means of conveyance for goods, &c., by either of the above plans, that for a given sum of money in each case, the turnpike road and the steam-horse, will give the best and cheapest results, whether it be in cost of construction, maintenance of way, or outlay in starting for working the traffic, and upholding it when started.

Roads can be maintained in working order at a far cheaper rate than either canals or railways; and there can be little reason to doubt that they can be constructed, in this country at least, far more cheaply than either railroads or canals, besides possessing the great advantage of being capable of construction, almost anywhere; and not so dependent on a supply of water in one case, and a prodigious fund of money in the other, to enable them to be carried out properly, and with the solidity required, to render them fit to take the traffic that may come on them.

In foreign countries, however, great natural obstacles exist to the formation of either railroads or common roads; and where this is the case, canals are generally quite out of the question, from the deficiency of a sufficient water supply, which alone enables canals to be of any use in such countries.

It is stated that animal power could not be used in the general traffic of the Brazils upon macadamised

roads with the same advantage which many other countries had derived from it.

Some of the gradients on these roads are stated to be very severe, varying from 1 in 6 to 1 in 9. One road, with an average gradient of 1 in 16, with its summit level about 2800 feet above the level of the sea, had only recently been macadamised, and it cost £40,000 per mile! although there were no disbursements for land, legal, or parliamentary expenses.

It seems extremely probable, in the case of the roads where animal power cannot be used, that in setting them out, the old English system of going straight at the ascent has been followed, rather than that of endeavouring to surmount it by ascending it in a diagonal line, *across* the line of inclination, by which means, it is true, the road would have been lengthened, but on the other hand the gradient would have been much lessened, and the ascent have been overcome with greater ease, or a larger load would have been more easily transported.

What the cost of railroads in that country is likely to be, may be conceived from the fact of all the materials having to be carried by animals; that one small bridge of cut stone, not 60 feet in length, had cost £24,000! and also that to make a macadamized road had entailed an expenditure of £40,000 per mile!

The following statistics, relating to turnpike roads in England, are so interesting that I give them in full, more particularly as they are from a source that may be fully relied on.

The gross expenditure of all kinds, in the year 1856, was £1,069,941; and in repairs only was expended the sum of £736,723, under the following heads:—

| | | £ |
|---|---|---|
| Manual labour | | 264,918 |
| Horse labour | | 111,415 |
| Materials | | 170,095 |
| Damage in obtaining materials | | 1,645 |
| Tradesmen | | 38,511 |
| Treasurers | £3,027 | |
| Clerks | 23,987 | 77,001 |
| Surveyors | 49,987 | |
| Law charges | | 25,946 |
| Statute labour, being composition in aid from parishes | | 3,673 |
| Incidentals | | 43,519 |
| | | 736,723 |

This sum divided by the total number of miles, 19,942, gives just the sum of £37 as the cost of maintenance; but if the maintenance of way be considered to be the gross expenditure, we then get the sum of £53 13*s.*, say £54 per mile, as the cost of maintenance.

The gross debt of these turnpike trusts amounts

to the sum of £5,848,645, of which sum £5,038,000 is *bonded debt*—the rest being floating debt and unpaid interest.

A turnpike road of, say 30 feet wide, with a 6 foot footway, would on an average cost £2,000 per mile for making, including land, fencing, drains, bridges, and culverts.

A parish road of, say 20 feet in width, may be taken as costing £1,000 per mile.

I am informed by an excellent authority, that the average cost of the maintenance of the turnpike roads in England in 1856, was equal to £37 per mile per annum, as shewn above, or a little less than one-seventh the cost of maintaining one mile of railway.

In England alone (not including Wales) there are 1063 turnpike trusts, containing 19,942 miles. According to the annual report on turnpike trusts for 1857, which has just been issued, it is stated that in England and North Wales, the receipts for the year were £1,091,863, two-thirds of which were absorbed by repairs of roads, salaries, and law charges; and out of the residue, bonded debt to the amount of £110,754 was paid off, and £175,850 paid for interest.

In 1837 the receipts from tolls alone amounted to £1,509,985; the changes of twenty years reduced

the produce of the tolls in 1857 to 1,030,956. In those twenty years the mortgage debt on trusts in debt, has been reduced from £7,011,989 to £5,117,308, which is secured upon a toll income that in 1857 amounted to £855,183, or about 16 per cent. on the debt. The unpaid interest has been reduced since 1849 from £1,587,010 to £776,882.

In South Wales the accounts are kept separately; there the receipts were £36,728. The South Wales trust is in debt to the Public Works Loan Commissioners, who advanced £217,020, which has been reduced to £153,011.

The above statements show what an immense sum of money is invested in the present road system in this country, and how important a subject it is, to render every reasonable facility and assistance to such a plan as could, without incurring any extra expenditure, or other drawback or inconvenience, enable this money to become of greater value; or afford a more speedy means of reducing the amount of the debt. That the employment of steam engines for hauling goods and transporting passengers, and inducing them to come on to these roads, would in no small degree tend to this end, cannot be doubted, nor that it would also confer a great public benefit on the community at large.

## RAILROADS.

Against the general and advantageous use of railways, it has been observed, there is this fatal objection, that where the traffic is inconsiderable, and consists of various articles to be conveyed in numerous directions, the difficulty of forming roads suitable for all parties, and the expense of branching them off to all the different parts where goods were to be carried, would operate to prevent the introduction of them, as a species of general communication.

However, it may be assumed that in nearly every case, where existing railways and turnpike roads come into competition, railways will monopolise all the traffic, whether it be heavy goods, light merchandize, parcels, or passengers. If, therefore, a railway is once constructed between any two points, the company may safely calculate upon being enabled to compete successfully with the turnpike road carriers, for all the traffic between the two termini of the railway. There is, however, a limit to this, which must not be overlooked; railways commence and terminate at certain points; to deliver goods, parcels, and convey passengers to different parts of the town carts and carriages are required; and as the transferring of goods and passengers from one

carriage to another is attended with expense and delay, the saving of conveyance by railway, may in certain cases where the distance is not great between two places be counterbalanced by the expense and inconvenience of transfer; and therefore in calculating upon the traffic which will be obtained by a railway we must take this into consideration.

It has been found for instance on railways where the break of gauge occurs, and which necessarily involves trans-shipment, that trans-shipment involves loss by misdirection and pilferage, as well as a detention of hours and an actual money tax of from 1s. 6d. to 2s. 6d. per ton. In proof of this the reader will do well to read the evidence taken before the gauge commission on this subject in 1845.

Here one great advantage of steam traction on common roads is at once evident, because the necessity for changing from one conveyance to another, or "handling" as it is termed, is quite done away with; and of the loss and damage arising from this "handling" one can hardly form an idea, though, the remarks in the gauge evidence will very satisfactorily shew them.

It may be fairly assumed that a railway would monopolise the traffic upon a given line of road, to the exclusion of any other system; but where speed is not of any great moment, there can be no doubt

but the traction engine and train would fulfil as efficiently, and far more cheaply, all that could be done by the railway, at a far greater and more costly outlay.

As compared with a common road, a railway is as superior as steam is superior to horse-power. But whilst ordinary highways are indispensable, the superiority of railways in respect of traction, is no reason for excluding the former from a portion of the advantages which steam power has conferred upon the latter.

The question of steam carriages has nothing to do with that of railways. It is purely and wholly a question of the relative superiority of steam power and horse power, and there can be no doubt of the immense superiority of the former, in all points of comparison with the latter.

It is stated that the average cost for construction of the English railways is £39,000 per mile; if we take the branch single lines at only £10,000 per mile, we see what an outlay is encountered in opening up one mile of road or country, whilst for less than the latter sum, a very efficient system of steam trains capable of working from ten to fifty miles in length of goods traffic, might be readily organised, instead of filling up the country with short branches, mis-called "feeders" ("suckers" would be better),

costing large sums, both in making and in repairs, and all tending to diminish the dividends, now ridiculously low in most lines.

The average cost of maintenance of English railways per mile per annum, as stated in the article "Railways" in the "Encyclopœdia Britannica," just published, amounts to the sum of £250 per mile.

The average cost of branch locomotive single lines in England can scarcely be reckoned much under £10,000 per mile. The amount of capital expended on English railways up to the end of 1858, was in round numbers £325,000,000, and upon this enormous capital the average dividend paid has amounted only to 3·75 per cent.

If it be considered that 5 per cent. interest is the marketable value of money in England, when invested in property of fluctuating value, or in speculative undertakings, it may be held as a rule, that all capital laid out upon such undertakings, which does not pay 5 per cent. interest, is a loss of capital by so much as the difference the interest represents under 5 per cent.

Now the English railways are shown to pay only 3·75 per cent. interest on £325,000,000; therefore there is a loss of 1¼ per cent. interest on £325,000,000, or in round numbers £4,000,000 per annum; a

sum which represents a capital equal to £80,000,000! It seems from this that the principles of political economy are little understood, or if understood are certainly not acted on, for they teach us that capital expended unprofitably, is a loss of capital to the country.

It is generally found that the passenger and goods traffic from country districts and small towns will not suffice to pay for the construction of expensive locomotive railways. It does not appear that the high speed of locomotive railways is necessary; for these reasons many parts of the country are not, and do not seem likely to be at present, provided with railway accommodation; and in order to put them upon an equality with the districts intersected by the locomotive railways, I propose to place them in communication with the trunk lines by adopting a regular system of steam traction for goods and steam passenger carriages on the Common Roads already in existence; which while it will enable passengers and goods to be transported faster than by the present system of horse-power, and with greater economy, will afford a good investment for capital, and can be put in operation at a reasonable cost and without much delay, it not being needful to wait while the roads are making.

We find many instances in England, where railways running through populous districts having

stations every three miles or so, do not afford accommodation to the local traffic. Many of the turnpike roads between large towns, especially in the manufacturing districts, have continuous rows of houses on each side throughout their entire length. Suppose the towns ten miles distant from each other, with a railway communication running near and parallel to the road, and having a station half-way between these towns.

This arrangement would accommodate the inhabitants living near the stations; but many of the inhabitants living along the line of road would have to walk two-and-a-half miles to get to the railway stations—the average distance being one-and-a-quarter mile. Taking the one-and-a-quarter mile to be done in twenty minutes—ten minutes upon an average to wait for the train—ten minutes to go by railway to either terminus a distance of five miles—the time occupied on the journey would amount to forty minutes.

Now, if this passenger could be transported from his own door in a vehicle travelling at say eight miles an hour, though there is nothing to prevent its being as easily done at ten miles an hour or more, to the nearest town three-and-three-quarter miles distant; only thirty minutes would be occupied on the journey; so that there would be a saving of ten minutes in

time, and one-and-a-quarter of a mile in distance. As the greater portion of the passengers living along the route of the railway have to walk or be conveyed at least one mile to the station; they must be transported some considerable distance, and have incurred some considerable cost, either in time or money, or as is generally the case, in both, before they arrive at the station. Such being the case, if a proper system of steam conveyance, both for passengers and goods were opened up on the existing public roads, in those districts where they would be required; and if also they were made to stop anywhere along the route, and take up even a single passenger—all the disadvantages just enumerated, which are inseparable from the present railway system, would thereby be avoided.

If once a commencement is made to establish a regular system of steam traffic on the common road with the above object in view, it will soon prove so remunerative to those engaged in it, and will be so favourably regarded by the public that it cannot fail to become generally adopted, and I believe the time is not far distant when this will take place. It should, however, be remembered, that it must not be set about in a desultory manner, or without due consideration before hand; nor should time, trouble, or money, be regarded in the endeavour to establish it in a proper system, with proper appliances; and it

should start with a determination to persevere in taking it through the little *contretemps* which may be expected to arise in carrying out an undertaking against which so strong a prejudice has existed, and to aid its advance so few practical men, it may almost be said none, have in any way lent a helping hand; and also to convert into belief, that deplorable ignorance, both as to its practicability, and economy, which has so long existed, as much amongst "eminent engineers" as amongst the "ignorant unlearned."

It should be remembered that railroads are useful for speed, and for the sake of safety, but not otherwise; every purpose would be answered by Steam on Common Roads, which can be applied to every purpose a horse can effect.

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## CANALS.

In proportion to the useful effect produced by a given power, at a uniform speed, the three modes of conveyance in general use may be classed as follows:—Canals, Railways, Roads; but in cost of construction they stand thus—Railways, Canals, Roads; and for cost of maintenance, Canals, Railways, Roads.

In the following pages it is intended to consider each of them, and under each head to include

expenses, both of construction and maintenance, as far as they could be obtained.

From the results of experiments which have been made with the view of determining the merits of canal carriage, when compared with railroads and common roads, it appears from the results given in the following table, that at slow velocities the traffic of given weights is conducted more economically upon a canal than by other methods of conveyance—that where the velocity exceeds four miles per hour the economy turns in favour of railroads; and that at high velocities the economy of the canal disappears, even when compared with the motive force required on a level turnpike road.

The following table of the useful effect in weights moved by the application of an equal power on the three systems of conveyance now in use will prove the above remarks :—

| Velocity of Motion in miles per hour. | On a Canal. | On a Level Road. | On a Level Turnpike Road. |
|---|---|---|---|
| 2½ | 55,500 | 14,400 | 1,800 |
| 3 | 38,542 | „ | „ |
| 3½ | 28,316 | „ | „ |
| 4 | 21,680 | „ | „ |
| 5 | 13,875 | „ | „ |
| 6 | 9,635 | „ | „ |
| 7 | 7,080 | „ | „ |
| 8 | 5,420 | „ | „ |
| 9 | 4,280 | „ | „ |
| 10 | 3,408 | „ | „ |
| 13½ | 1,900 | „ | „ |

There can be no doubt that artificial or other inland waters form, up to a certain point, a medium of conveyance upon which can be transported, at a very small expense, and with a smooth or easy motion, but at a low rate of speed, all sorts of articles; but they are especially adapted for those which are very heavy, very bulky, or which could not well bear rough carriage.

In these respects, inland navigation has greatly the advantage of common roads, and is often preferable even to railways; and besides, in many cases where a ship has to be unloaded, and cannot be brought up to the railway, goods can be loaded immediately from, or unloaded into, a canal boat, which, by running alongside the ship, thus avoids a second loading or unloading. Canals are frequently enabled to combine the advantage of aqueducts and of drainage with navigation; but they can never compete with railways, where speed in travelling is required.

In spite, however, of these advantages, there are many serious drawbacks and accidents to which canals are constantly liable, which detract to a very great extent from their usefulness, and often render their maintenance a rather expensive operation.

For instance, it frequently happens that canals have to be formed more or less in, and embankments

have to be made of, materials of a very porous description, so much so as to frequently admit of the escape of the water by filtration. When once in such a case, the water has obtained a very small egress it gradually washes it wider; so that sometimes in a few hours a breach may be formed sufficient to empty the canal and require weeks, or even months, ere it can be repaired.

It is found, again, that the inside slope soon becomes chafed and indented at its upper edges by the motion of the water, which is caused by the passing of boats; and this abrasion often penetrates so much as to diminish irregularly the width of the towing path. This may not appear to be of much consequence, but when it is remembered that the washing of the banks of a canal not only destroys its security, but diminishes its depth, and the facility with which it is navigated, it will be seen that this is a serious occurrence which needs the best attention directed constantly against it, in order that its pernicious effects may be as much reduced as possible.

Another very great and serious evil to which canals are subject, and which may prevent their use for weeks together, is that of being frozen up. In this case, they become not only useless, but positively injurious to trade, by holding or detaining, instead of

the delays arising from these causes when they occur in a busy time, carts and horses are not preferable.

There have been instances of goods being longer on the way by canal from Liverpool to Manchester, than from New York to Liverpool; and these delays have frequently obliged the spinners to cart their cotton on the public high-road, a distance of thirty-six miles, for which they paid four times the price which would have been charged, and they were three times as long getting it to hand.

The introduction of the railway system, and its competition with canals, soon brought them into life and activity, although they had been in a stationary state almost ever since their introduction into this country. One of these first attempts of the canal owners was to increase the speed of the boats used for the conveyance of passengers; and for this purpose improved forms of boats were introduced, and a velocity was by this means attained, with the use of horses, that at one time it would have been considered almost insanity to entertain; and the wonderful advantages to be obtained by the use of steam as a propelling power has long attracted the attention of canal owners; but up to the present time its employment is only partial, chiefly arising from the want of some propelling arrangement, which shall not cause the water to damage the banks.

Amongst the numerous engineers and gentlemen who addressed themselves, some thirty years ago, to the discovery of a form of boat that should enable a high rate of speed to be obtained, and at the same time avoid the wash and disturbance of the water during its progress—a most fatal accompaniment of all the forms then known and tried, and one which it is vitally important to its success for canal navigation to avoid—Mr. Scott Russell must be considered the most successful.

This gentleman, the well-known introducer of the wave-line system of construction in shipbuilding, now universally adopted where speed is required, though its source is not always acknowledged, succeeded in obtaining a very high velocity, extending, I believe, in one instance, to over sixteen miles an hour, without any disturbance of the water; but in spite of all these improvements, canals are totally unable to compete with railways for fast passenger traffic. It may be remarked, that it will be generally found that the railway is shorter than the canal; and if the speed on the canal be taken at ten miles an hour, and on the railway at twenty—and though the railway fare be the same, or even double—all the conveyance of passengers will be absorbed by the railway. It may also be assumed, that where the distances are equal the railway will still have the advantage, even if the

speed be kept down to ten miles an hour, and horses be used as the motive power.

It was soon found that the attempts to run these boats at sufficient speed to enable them to compete with coaches on common roads for passenger traffic, could only be accomplished at a great expense for horse power; and as they were not quicker in their transit than stage coaches, they utterly failed in the competition both with them and railroads, travellers generally preferring to finish the trip quickly, even at a higher cost.

On the ordinary canals, almost everything connected with them is unfit for any greater velocity than that usually obtained; the locks, the tunnels, the bridges, the obstruction caused by barges and other slow running craft, which cannot be easily moved out of the way, and the slightest covering, even of broken ice, which caused a serious resistance, all were found to be detrimental to its continuance, whilst a hard frost shut them up altogether.

The great advantage in the transport of goods and heavy loads by water conveyance, is the smallness of the power required. A body floating in water is left so very free in its movements that motion may be gradually communicated to it by any power, however small: at least, the limit is very far removed; but although a very slow movement may thus easily be

obtained, the slightest increase of speed causes a very great increase of resistance.

There is no doubt that canals form an economical means of transport for heavy loads in large masses, at low speeds, after they are constructed; but as they cannot be made in all localities, are expensive to make, and also to maintain when made, and do not accommodate traffic so easily as the existing roads, they are not, under all circumstances, to be considered preferable to the common road, especially when steam power is used on it.

## SUBSTITUTION OF STEAM FOR ANIMAL POWER—ITS ADVANTAGES.

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Of all the mechanical contrivances of modern times, the steam engine is acknowledged to be the most important, and justly so, aiding as it does the printing press, the great agent of civilisation.

To enumerate the many benefits the human race have derived from it would be almost impossible; it has penetrated the earth, and drawn therefrom, not only the mineral wealth hidden there, but that fuel, also, which puts life and animation into the machine itself.

Much of the slavish toil endured by our forefathers, both in their manufacturing and agricultural pursuits, has been dispensed with by its application, and is succeeded by a comparatively light superintendence.

By its influence land and sea are traversed with an ease and speed entirely unknown before its introduction, and mankind are thus enabled to effect an intercourse with the remotest nations on the face of

the earth; and the mutual opponents to the navigation, wind and tide, are successfully encountered and vanquished.

The iron horse harnessed to our carriages, laden with the heaviest goods, outstrips the fleetest racer, and in comparison leaves the carrier pigeon far behind, thereby enabling the merchant and traveller to reap the benefit of this mighty power with an economy, both in time and money, utterly unattainable by any other means.

Seeing that steam has proved such a great economy in every branch of manufacture to which it has been applied, we surely cannot think that agriculture *must* be an exception.

The substitution of inanimate for animate power has, from facts and experience, as may be seen in the foregoing pages, been proved to be easy of operation and effectual in its results; and as the natural tendency of every operation, in these days of progress, is (or should be), to obtain the greatest return for the smallest proportionate outlay, I have no doubt that, within a few years, we shall see steam applied to most of the work now done by horses; and with what result to the community at large, I shall avail myself of portions of a valuable and interesting paper "On the Forces used in Agriculture," lately read at the Society of Arts, by Mr. J. C. Morton. He says:

"Agriculture is, in fact, experiencing the truth taught in the history of all other manufactures—that machinery is, in the long run, the best friend of the labourer. This truth is taught even more impressively by a review of agriculture generally, than it is by the case of any individual farm. Here are we, twenty-one millions of people, producers and consumers, living in this island, on a great farm, which we may—by the help of such statistics as we possess—describe as nearly 19,000,000 arable acres, and probably nearly as much grass; employing as farm labour, indoor and out, about 950,000 men and 120,000 women, besides 300,000 lads, and 70,000 girls; or, averaging them by their probable wages, as has been done before, let us say, equal in all to 1,150,000 men, or one to every seventeen acres of arable, and nearly as much pasture. We feed and use some 1,500,000 horses, of which, probably, 800,000 are strictly for farm purposes.

"We are annually inventing and manufacturing labour-saving machines at an extraordinary rate; and every year at least 10,000 horses are added to the agricultural steam power of the country, certainly displacing both animals and men to some extent. We have taken the flail out of the hand of the labourer, and the reaping-hook is going; on many a farm he no longer walks between the handles of the

plough—he no longer sows the seed—he does but a portion of the hoeing and harvesting; and yet, so far from being able to dispense with his assistance, he is more in demand than ever he has been. That the services of the labourer will more and more require the combination of skill with mere force, and that a larger number of well qualified men is being, and will be needed, seems plain. That horse power will be displaced by steam, at least two-fifths, I believe; and as there are now at least 800,000 horses used upon our farms, there is scope enough for many years to come for all our agricultural mechanics.

"That the working man is benefitted by the use of steam on farms is evident from their having, as it were, decreased in number, so that they are scarce, and higher wages becomes the rule; but the fact is, that steam opens up so much more work to be done that their present number of men on the old system is not sufficient.

"A labouring man, working with the steam plough, was asked, 'How they answered?' The reply was characteristic and amusing: 'They answered exceedingly well, as *he got half-a-crown a day wages.*'"

Mr. Morton also remarks, "there are two considerations which greatly affect the position of horse-power in this competition with steam, and place it much further back, than it would at present seem to

be. They both affect its fitness for those acts of cultivation where it is plain that there is the greatest room for an extended use of steam-power. I refer —firstly, to the injury done to the land by the trampling of draught animals; and secondly, to that irregularity of employment on the farm for horses during the year, which in effect makes you keep upon a large farm, several horses all round the year for the sake of their work during a few weeks of spring and autumn. If a steam engine, which *costs nothing when it is idle*, can be used to take this extra work, and so reduce the horse labour of the farm to an uniform monthly amount, then its cost has to be compared, not with that of the horses, which it has displaced during those few weeks in question, but with the cost of those horses throughout the year. It is this fitness of the engine for the cultivation of our stubbles in autumn, and to its power to displace so many teams throughout the year, which would otherwise be kept just for the few weeks of more laborious time, that greatly heightens the economy of its employment.

"All recent improvements of the soil have proceeded upon the idea that there is no necessary distinction between it and the subsoil; that thorough drainage and deep cultivation, both increase fertility, and that the existence of anything like a 'pan' within

30 inches of the surface is injurious. The ability of steam power for the deepest cultivation, and its applicability at the same time to the thorough cultivation of any depth to which it may be desired to stir or turn the soil, without any pressure except by the wheels of the implement employed, must ultimately obtain for it the preference over horses for all mere ploughing and stirring, especially of clay land, and a very large share of the horse labour of ordinary agriculture will thus be handed over to the steam engine. It appears that on arable lands, two-fifths of the horse labour of the farm can be handed over to a power which is capable of nearly twice as much duty, at about one-half the expense."

Now, it is estimated that each horse consumes as much food as is necessary for the support of eight men. Mr. Morton, in his paper just quoted, estimates that we employ one-and-a-half million of horses; if, therefore, steam could be substituted for this number, and the food consumed by them converted into food for human beings, we should be enabled to feed no less than 12,000,000 extra population.

If we only take the extra amount of people capable of being supported, at one-half the number above, or 6,000,000, we shall find that it would more than satisfy the mass of poverty and pauperism which prevail in this country to such an enormous extent;

and this saving would not require more extended agricultural operations, or a greater outlay, but would be just that part of the annual produce of this country which, as a whole, is at present required for the mere purposes of transportation, that is, to feed the animals used for draught, and is consequently a dead loss as unproductive capital.

Whilst this system lasts, and the country is burdened with poor, and the strongest and ablest workmen are obliged to emigrate, we are virtually wasting our strength, and receiving no benefit in return; and it is truly said that we are depopulating our country for the "brute," though we have a good, hard working, cheap, and simple remedy before us, which prejudice (in many cases) prevents us from adopting.

From animal power being everywhere limited as to its powers, and also expensive in its application, it is evident that some more powerful agent—one that will be more economical in working—becomes necessary; and for this purpose there is none more powerful, useful, cheaper, or more manageable than steam; and steam power, at an equal or slightly superior rate of speed to that maintained by horses, will be found much cheaper than horse power—in fact, less than half the cost.

Farey, the celebrated engineer, in speaking of the advantages of steam locomotion, says of the engines:

"They can be laid up and kept idle without considerable loss, and brought out again when wanted without any new outlay; also, fuel does not fluctuate, either in price or quality, to any considerable extent like horse corn."

It was observed by Mr. Morton, in his paper before quoted, "That by steam power at *least three* out of every seven horses on arable land may be dispensed with *all the year*, at a cost not exceeding the cost of these horses during the *three or four months*, when alone they are needed on the land."

Looking at the great number of horses which must *first* be bought, and *then* kept, whether *working or idle*, to do the same amount of work as one engine —the *first* outlay will not exceed, for the steam engine, the cost of horses by more than one fourth. The daily expenses of fuel and attendants will be *very much less*, in proportion to the amount of work done, than that of horse keep and attendance; the wear and tear of waggons, and wheelwright's work, will not be more than at present, but the wear and tear of engines and machinery, though an expensive item on each engine, will be nothing to compare with the present repairs, loss and decay of horses, because the number of engines required would be so small. Engines, with an equally heavy annual expense of repairs to that of horses, will, if well and properly

constructed, be kept up thereby in such a state as to last for many years without renewal. The metal portions of the machinery only wear at particular places, which are capable of being repaired or renewed, so that they become as good as new; but a horse, when worn to disease at any part—feet, eyes, or lungs—becomes incapable of renewal, and then soon decreases in value and return for the original and daily outlay.

On this subject, Farey made the following observations: "Steam power is certain to be more profitable than horses if the work is to be kept constantly going on, because the great advantage of steam power, that it does not tire, becomes fully available; and to perform the same service by horses, a very great number must be kept for change. The profit of working by steam, *in lieu of horses, is very great.*"

Seeing that steam has been introduced with the greatest success for the purposes of locomotion, by land and by sea, and is also rapidly extending into every branch of manufacture, both in this kingdom and other countries, there can be no reason to doubt but that it will soon become as general a servant to agriculturists as it is to the manufacturer and the public.

It has often been remarked, that it is a surprising thing that steam has not been more employed by the farmer, when its universal success in all other opera-

tions is so evident; but we must remember that the British farmer is a slow-going, not over progressive individual, and one who dislikes a "new fangled" plan; is generally averse to change, and can only be managed by touching his "breeches pocket," *i.e.*, *his money*—showing him that he cannot compete with steam, and that whoever adopts it is enabled to undersell him if he choose, and if not, to make a greater profit than he can.

We can all remember how, a very few years since, the introduction of the thrashing machine, to be worked by Portable Steam Engines, was ridiculed by many, and the result doubted by still more; but the thousands of those engines now at work testify to their complete success, and they are now frequently owned by individuals who get a very tidy living by going with them from farm to farm, and thrashing out the farmer's wheat, &c., at a certain price; which, whilst they make a good living, is still such as gives the farmer a considerable saving, and consequently a greater profit, besides enabling him to get his grain to market much earlier, in better condition, and at a cheaper rate.

It therefore becomes very evident that, as steam has proved itself so valuable in the comparatively unimportant operation of thrashing, it cannot fail to be equally—I may say more so—in the more important

one of the cultivation of the soil, and the still more general purposes of the farmer; and there can be little reason to doubt that it will, before long, become the regular "horse" of the farmer.

It is now pretty generally admitted that the rope system has had a fair opportunity of proving its success, but before a person can fairly recommend a farmer to exchange horse power for steam, he should at least be prepared to show that, taking all things into consideration, there should be a very wide margin of profit to warrant the change.

Seeing what a great difference there is between the cost of the keep of the horses, and the cost of coal, &c., for a ten-horse engine, the farmer is surely entitled to look for something of that difference, when he substitutes an engine of that power for an equal number of horses ploughing.

I have shewn, under cost, that the average consumption of coal per acre, when ploughing by steam, has been found to be 1¼ cwt.; and taking the work done, on an average, at twelve acres, and the cost at 52*s.* 6*d.* per day, we have 4*s.* 4*d.* and one-third of a penny as the cost of ploughing one acre by steam.

It has been assumed by the advocates of the rope system, that on an average, two hundred days' ploughing per year takes place on a farm. It has been stated, on equal authority, that one hundred

days are quite enough, and with this estimate I am inclined to agree; and it has been found, from actual experience, that ploughing is from four-tenths to five-tenths the amount of horse labour.

In all rope traction it is of great importance to know that a great amount of waste, both of power and material, takes place when the ropes are bent or pass round pullies; and the power consumed or wasted on this principle is very great. It has been admitted that an 8-horse engine is not quite able to haul two ploughs, when a steam horse power is considerably greater than that of an ordinary draught horse.

It is a well known principle, but one not much attended to by the advocates of the rope system, that the friction arising from the bending of ropes, especially wire ones, increases at a far more rapid rate than the mere increase of rope thickness and strain. In other words, a rope capable of bearing the working load of twelve horses, absorbs far more than twelve times the power in friction than the small rope capable of bearing the working power of one horse.

Instead of the friction being twelve times, it is stated to be one hundred times greater, or thereabouts. When wire rope is used, the friction is greater still. All this additional friction is not only

taking up power, but using that power to grind away the rope and machinery, it being a well known fact that all the rope systems consumed a greater or less amount of power in the friction of their ropes and pullies.

It will be sufficiently evident, then, from these considerations, that something different from the rope system is required before steam cultivation can be rendered generally profitable to the farmer.

The *Practical Mechanics' Journal* for March has the continuation of an able article on steam cultivation of the soil, from which the following is an extract:—
"In proceeding to inquire how the land may be profitably cultivated by the aid of steam, we regard the plough as the implement on the use of which all calculations should be based, and with its valuable assistance will be practically solved that all-important problem—will steam cultivation pay?

"It is necessary that we should now make some comparisons of what has been already accomplished, which it is hoped will not be considered invidious, seeing that the welfare of thousands, and the good of millions are concerned in the present inquiry.

"When, at the show of the Royal Agricultural Society, Chester, Messrs. Boydell and Fowler worked during the public day in the same field, there was a good opportunity afforded of forming a pretty correct

opinion (independent of any other circumstances) as to which of the two principles of applying power is the best; for both were subjected to the same conditions.

"Mr. Fowler's engine was a double cylinder 12-horse, working with 60lbs. steam; Mr. Boydell's the same, or nearly so. Both of them were computed, by competent judges, to be working up to 20-horse power, if tested by the dynamometer. What was the result? Mr. Fowler's engine drew four ploughs at three miles an hour, cutting furrows six inches deep; while his competitor worked *six ploughs at the same speed, turning furrows to the depth of eight inches; which was considered double the work executed by Mr. Fowler's engine.*

"If the engines were both working up to the same power, why did not Mr. Fowler do as much work as Mr. Boydell? For this simple reason, that Mr. Fowler's power was LOST by circumstances over which he had no possible control.

"The traction engine brought out by Mr. Boydell, may be unsuited to the farmer's use, it may be unmechanical even in its construction; but it is quite possible to judge, without prejudice, of the *immense advantages that the direct traction method has over its complicated and expensive rival.*

"Some may ask, why has not Mr. Boydell succeeded

better if the principle upon which he works is the correct one? Although Mr. Boydell may have proved it to be correct, he may have been unfortunate in his practical demonstrations, either through the peculiar build of his engines, or an improper adaptation of the principles of locomotion.

"Another point in favour of locomotives of proper construction is that they will work every day. *Not so with stationary engines, for they require to be shifted, together with the anchors, implements, and gearing, at least once in four days, at a great cost for horse power and labour in fixing the anchors, &c., and adjusting the tackle, besides a loss of 20 per cent. of the valuable and seasonable time in which their services are required and are available.*"

The above contrast of the two systems, which shows so clearly the disadvantages of any system of traction by ropes, and any other arrangement for applying the steam power in a different manner than horse power, viz., direct traction, proves that they will not, I feel convinced, be of any extensive adoption in this country.

In the same number of this journal are the following remarks:—"Few of our readers are probably aware that Mr. Gompertz was one of the earliest, if not really the first, to propose the use of an 'endless railway' for wheeled carriages, such as we now see

carried out in the various 'traction engines' which have been brought to something like perfection."

Now, I beg leave to differ *in toto* from that statement; and in reply, would refer the writer of it to my sketch of "Distributed Weight," where may be found the particulars of patented "endless railways" from 1770 down to the close of 1858, which, I doubt not, will be considered a satisfactory proof of the truth of my remarks. I do not say that Mr. Gompertz never tried his hand at the "endless railway;" on the contrary, I think it extremely probable that he has done so, as I have known him by name for many years as a very persevering and sometimes successful inventor.

In the *Mechanics' Magazine* for the 23rd of March, 1860, I found some interesting remarks on the "Steam Plough," which were read before the Royal Scottish Society of Arts, during that month, by Robert Aytoun, Esq., and from which I make the following extracts:—

"The admirable exposition on this subject lately given to the society by the Professor of Agriculture in the University of Edinburgh, must have left a very general impression that steam culture is sure to supersede every other; and that its universal adoption is only a question of time."

At present, however, this is far from being the

case; the saving of expense is not so decided as to warrant its adoption on the score of economy alone, and none but those farmers who are willing to spend money for the advancement of their art, have as yet ventured upon the costly experiment.

The reason why the expensive power of the horse has been able to compete successfully with the cheaper power of steam is that in the former case the plough is *directly attached to the horse and receives the whole power exerted by him;* while in the latter it is connected with the steam engine, *through the intervention of a long rope and pullies, which necessarily absorb a large part of the power, besides being expensive in attendance and repair.*

But if such are the disadvantages of the present mode of ploughing by steam, how does it happen that our inventors have adopted that artificial and expensive plan, in place of the seemingly simple, natural one of employing the locomotive itself with ploughshares attached, to traverse our fields and turn up the soil as it goes?

This leads to the consideration of the only other difficulty in the way of the locomotive plough. Its great weight may cause the wheels to consolidate the soil to its injury, or even to sink so deeply in it as to arrest its progress. But the effect of the weight depends entirely on the extent of surface with which

it bears upon the soil; and as we can augment the surface by increasing the diameter of the wheel and its width, it is apparent that we have it in our power to reduce the pressure per square inch to an amount which experience shews to be safe. (See the remarks on Distributed Weight.) Suppose a horse to weigh 15 cwt., and its foot to have a bearing surface of 15 square inches—when in motion it rests upon two feet only at a time, each square inch of which must therefore bear on the ground with the pressure o 56 lbs., or ½ cwt.

A locomotive, weighing ten tons, would only require a bearing surface of 400 square inches in order to press on the surface of the ground with the same force as the horse, and would open up ten or twelve furrows at a time.

If the horse were a machine, not subject to fatigue, capable of being continually worked up to the maximum tractive efficiency that the weight of his body gives, capable of having the efficiency of many individuals combined in one; and if he was a consumer only when he was at work, he would then be a most thorough artificial aid to man, and would furnish an unlimited supply of economical physical force, suited to the requirements of the farmer, capable not only of the performance of one duty, but that of all those

various operations, each of which constitute an item of cost in the value of produce.

In attempting, therefore, practically to apply steam to agriculture, an effort must be made to embody in the machine those qualities which such an animal, as described, would possess; and then would the use of animal power be dispensed with, and steam reign supreme over all the operations of this branch of industry.

This desirable end being carried out (as must inevitably be the case), the use of the locomotive will be extended to all the steam processes comprised in the cultivation of the soil, such as subsoiling, scarifying, harrowing, breaking, and rolling, all of which will be done in a far superior manner to the present; partly because these processes will be performed without pouching the land, and partly because their expense will be so trifling compared with what they would be by horses, that the farmer will grudge no operation or process by which good tilth may be secured.

He will, also, by judiciously and gradually increasing the depth of the furrow, bring up new soil to refresh the old, a process which is found necessary for the continued vitality of roots; thus, as has been said, extending the limits of the farm downwards.

In short, fields will be cultivated as gardens are now. But what does that imply? Abundance and cheapness of food, such as the world has never seen since our first parents were driven out of Eden.

The locomotive steam plough will be welcomed into Jamaica, and our other West India Islands, as a true friend, which will restore the prosperity they have lost from scarcity of labour. It may also be welcomed by the go-a-head planters of America as the cheapest means of raising crops.

The *Times*, speaking a few weeks since of the advantages of steam cultivation, says, "Of course the results vary extremely, according to the character of the soil, and the extent of operations; but in *all cases the steam engine has proved its superiority to the team*, and given satisfaction to the farmer.

"A wet autumn may have been disadvantageous to the steam cultivator, but a dripping summer has given full proof of its superiority to a horse-worked implement; the power to get forward with the tillage has enabled farmers to be hoeing and singling out turnips, while their neighbours with the horse system are scarcely able to sow; and already many farmers, having completed their green crop preparation, are carting out manure in readiness for next year's fallow. It is clearly established by the experience of the past year, that crops on the steam-

ploughed land are less dependent than others upon the vicissitudes of the weather. The more deeply worked soil, untrodden by horses, and tilled in good time, is found to be moist when other land is suffering from drought; the corn is stout and flourishing, while ordinarily managed crops are flaccid and weak, the difference of produce in favour of steam tillage being fairly reckoned as at least eight bushels per acre.

"The first cost of an engine and apparatus is great, but the universal experience has shown that one-third to nearly one-half the force of horse-teams is displaced without fettering the operations of hay, harvesting, or other carriage; so that on large holdings the horses sold off bring a handsome contribution towards the new purchase. In working it is found that there is not only a saving of cost in each operation as compared with horse-work, but there is a further saving in the number of operations, owing to the greater efficiency of the steam tillage, a source of economy amounting to, say, 30*s*. an acre on the fallow portion of the farm.

"The power of being able to economise time and prepare ground in the most suitable weather, has conferred the advantage of being able to take crops in more rapid succession without fouling the land, besides insuring an increased yield of all crops; so

that the mere cheapness of any one process in comparison with work done by horses is of little moment, though this point also is well met by the steam machinery. The profits on large farms are shown to be very great, more especially in strong soils; on smaller occupations, also, the advantage is thoroughly demonstrated.

"On 250 to 300 acres of arable, four to six horses are dispensed with, and the expense of the animals now saved does more than pay for maintaining the steam plough, &c., in proper efficiency, and for the interest of capital invested in the machine. The actual working expenses therefore represent the cost of the work done—that is, 25*s.* to 30*s.* per day for six to ten hours of ploughing or deep smashing up, or 5*s.* down to 3*s.* per acre, according to the heaviness of the land, and the depth burrowed by the share. *The steam plough, in fact, now gives, for half the money, work of more than double the value of horse power tillage.* Reckoning the coal at 1*s.* per cwt., allowing good wages, and including water, &c., the daily outlay would be about 36*s.*, or 4*s.* per acre—*just half the cost by horses!*"

The following remarks on the rope system, are extracted from a lecture at Reading, by Mr. Williams, of Baydon, which he delivered a short time since:—"The length of rope required to plough a furrow of

only 181½ yards, will be, in Fowler's system—"long range," as it has been called—380 yards; ditto Triangle, 771 yards; Chandler's and Olivers, 781 yards; Smith's, 907½ yards.

"I have always held, and freely given, my opinion, that the power should be sent *direct from the engine to the furrow.* The fixed engine system appears, at first sight, to be very simple—like thrashing a wheat rick—*but nothing can compensate for the continual friction, wear and tear, and loss of power necessary to run so many pullies, and at such a distance from the work.*

"I am inclined to think that our root crops (so indispensable to the farmer in the present day), will be increased by at least three-fourths by deep steam cultivation.

"I have taken the pains to ascertain the number of footmarks per acre made in a field, where I saw several teams, three horse each at length, and all, of course, walking in the furrow. I measured one chain, or twenty-two yards, and the number of steps each horse made within the distance amounted to 164. Now, there will be eighty-eight furrows, nine inches wide each, to the chain; and the horses will have to travel 880 chains, or eleven miles, to plough an acre; consequently, as 164 steps were made in one chain, the moderate quantity of 144,320 were

taken in ploughing an acre, besides treading on the headlands, and every one with a pressure of something like four cwts. It is not surprising, therefore, that wet land should continue wet under such treatment. I have often seen four horses at length, and this, of course, would add 48,107 more steps per acre, or 192,427. The avoidance of this treading I look upon as one of the greatest advantages incident to steam culture.

"Autumn cultivation ranks next: for however farmers may wish to break up their stubbles immediately after harvest with horse power only, they can only accomplish a small portion. The steam engine will here meet the difficulty. In the spring, too, if dry weather, how anxious the farmer is to do double what his horses can do. I know this from the numerous applications I have had to plough and cultivate by hire. Here, again, the engine will be advantageous, more especially as she never tires, and only requires the men to be paid overtime, and a large amount of work can be done at the best season for doing it."

When Mr. J. Gibson was being examined by the Committee of the House of Commons, in 1859, he stated his opinions on this subject as follows:—"If the Committee will allow me, I will state what my general views of the thing are. If stone could be

brought by the traction engine and train at 1*d.* per ton per mile, and 3*d.* for the bars for the distance, that would be 1*s.* per ton, for which there is now paid 3*s.* 4*d.*; large quantities of rubble stone is left, and cannot be sold; it cannot now be delivered in Manchester for less than 4*s.* 4*d.* per ton; 4*s.* 4*d.* per ton, I believe, is a little more expense in foundation for buildings than bricks. If it could be delivered by this engine and train direct to the building for 2*s.* per ton, it would give a very great advantage to the public, and enable the stone-getter to sell a large quantity that is now thrown away, and buildings would have a much stronger foundation at a less price than brick. The same thing applies to coals; we pay 3*d.* and 4*d.* per ton for carting, and within a circle of little more than two miles from us there are six other owners situated the same as we are. If coal could be delivered direct to the customer for 2*s.* per ton, the engine to take the coal from the pit on large waggons, say eight tons each, in four boxes, to be lifted on the waggons with a crane, and taken to a depôt at the edge of the town; then lift them on to the bottom of a cart made for that purpose, and deliver them with horses to the customer, it would save 1*s.* 4*d.* per ton; that would enable the coal-getter to come into the market, he would very soon double his quantity got, and, of

course, the consequences would be a better profit to him, and the public would get the coals for less money. It would bring very large coal and stone fields into the market that cannot now be worked to pay. There are quarries standing now, one of which belongs to the trustees of the Duke of Bridgewater, because they cannot take stone into the market to make it pay. Then as to horses being frightened, I will state what my views are upon that subject: I keep fifty horses, and I am perhaps able to form some opinion upon that point. I think that horses are a very great nuisance on the road; strings of carts of ten or twenty get together, and a very rude lot of men; sometimes you can scarcely pass safely. The men, I think, are as great a nuisance as the carts and horses—they are so very unruly. If sixty tons could be taken in one train, it would take off the road thirty horses and twelve of these rough men. You would only require three men for each train, who would be a better class of men, and three times the quantity of traffic would be done with much less confusion."

With these remarks of Mr. Gibson I fully concur; having, as elsewhere hinted, experienced on several occasions whilst with the engine, the nuisance complained of; and as he very clearly shows the increased amount of traffic these engines would

bring upon the road, at the same time that the wear and tear on the road is much decreased, I think it is pretty plain that it would be beneficial to the trusts if the absurdly exclusive tolls, at present sanctioned, were reduced to a fair ratio.

Mr. Gibson stated in continuation—"When I went to Chester I saw this engine, and it at once struck me that it was the very thing to relieve our part of the country by enabling us to carry coal without the use of horses. If we could bring our coal into the market by these means, we should have nothing but the shilling per ton to pay, and we could then compete with other parties who now beat us, coming thirty or forty miles on railways, and who can bring coals from Sheffield for quite as little money as we can cart them eight miles. That part of the country really wants relief of some kind. I should put eight tons on each waggon. If they had come at two miles an hour they would have brought fifty tons as easily as they brought thirty. It is also thought that these engines might be made very useful in the removal of night soil from large towns; at present we are tied down to certain localities, and when it gets to a certain place it has to be carted five or six, perhaps seven or eight, miles. If we had this engine to load it at Manchester, and to take it direct to the farmyard, we should then get our night

soil removed at a small expense. At present the bulk of our night-soil goes into Lincolnshire by railway; whereas if we could take it down into Cheshire by means of this engine, it would be carried at a small expense, and a market would at once be found for it."

Since the application of steam power as a substitute for manual and horse power, varied proposals and plans have been submitted for rendering it of practical value in farming operations. The portable engine, for example, is now of almost universal use. Its application to the thrashing machine has become an important, and to the farmer, almost indispensable auxiliary. The reaping machine is another valuable invention, the practical value of which can scarcely yet be appreciated; but which is capable of becoming an immense aid to "successful farming."

In the United States "one hundred and fifty of these reaping machines have been seen at one time cutting down the ripe corn, whilst one thousand men, women, and children were following after binding and shocking up the golden sheaves." It is described as a sight worth seeing to behold the grain falling and being gathered up at the rate of 200 acres per hour! Astounding as these facts appear, agricultural science has not yet reached its perfection. Although it is only about eighty years

ago that the first swing plough was invented by James Small, a humble Scotch wheelwright; the rapidity with which agricultural implements have been adopted, has given an impetus to invention and mechanical ingenuity, almost more than any other pursuit, and whilst agricultural operations have thus been furthered, the commerce of the country has been correspondingly increased; and a numerous and wealthy body of men have sprung into existence, employing an immense number of mechanics, whom we denominate the "Agricultural Implement Makers" of this country.

That there would be a real and great gain to the country from the substitution of steam for horse power in ploughing, is capable of easy demonstration.

It is well known, and universally admitted, that where steam power is employed, and there are facilities for obtaining fuel, it supersedes all other agents for effect and cheapness; but in comparison with horse or animal power this is especially the case, for if the period of productive labour be set against that of rest and unproductive labour, the most startling results will be exhibited.

Assuming that horses are fed and tended 365 days of 24 hours, or 8,760 hours a year, and that they only work 300 days of 8 hours each, which may be

taken as the mean throughout the year, the result is 2,400 hours work per year. Now 8,760 — 2,400 = 6,360 hours unproductive.

Taking the number of horses employed in agriculture in Great Britain, as a mean, at 1,200,000, the cost for maintenance of this number, at £25 per annum each, a low estimate, is £30,000,000 per annum, the amount paid by the agriculturist for horse keep alone; and if the unproductive portion = 6,360 hours be deducted from that sum, the amount of which is £21,785,306, it will be seen how small a proportion of that vast outlay can be considered as usefully expended, particularly if it be remembered that the loss of this £21,785,306 per annum can only be considered as expended in producing manure; and it will at once be seen, from these figures, that the use of some more efficient and less costly agent is very necessary.

Another thing may be remarked, and that is, that economy of time does not claim that degree of attention on the part of agriculturists generally, which it so strongly merits; and they seem, as a body, to be rather unmindful of the truth of the remark, that "time is money."

The hours of daylight, in each month, are seen to be as follows :—

| | Hours. | Min. |
|---|---|---|
| January . . . . . . . . . . . | 230 | 46 |
| February . . . . . . . . . . | 285 | 54 |
| March . . . . . . . . . . . | 366 | 46 |
| April . . . . . . . . . . . . | 405 | 6 |
| May . . . . . . . . . . . . | 485 | 15 |
| June . . . . . . . . . . . . | 494 | 19 |
| July . . . . . . . . . . . . | 497 | 9 |
| August . . . . . . . . . . . | 449 | 37 |
| September . . . . . . . . . | 377 | 49 |
| October . . . . . . . . . . | 328 | 43 |
| November . . . . . . . . . | 260 | 50 |
| December . . . . . . . . . | 235 | 42 |
| | 4,419 | 21 |

Of these 4,419 hours of daylight, horse labour is only available for 2,400 hours, and human labour the farmer cannot afford to employ as a substitute.

In the long days of spring, summer, and autumn, he has not sufficient of the animal power to occupy the time; but in winter, three-fourths of that period he is feeding stock, producing no return but manure, and that by no means proportionate, either in quantity or value, to the quantity and value of the material expended in producing it. These may be considered insuperable difficulties attending the employment of vital power; but mechanical power puts forth its energy when called for—it can be regulated, and at pleasure stopped.

If it is desired to occupy the entire hours of daylight—to extend the field of operations—to work up

more raw material, the energy of the animal ceases after a time; but not so that of the machine. The longest hours of summer may, by its aid, be advantageously and fully employed.

Were the whole period of daylight industriously employed in the most useful manner—that is, by the use of steam machinery—the demand for human labour would be augmented in the exact ratio of the increased time, multiplied by the augmented force of machinery; and this is demonstrated in the power manufactories, where, since the employment of machinery driven by steam, the employment of labour has increased a hundredfold.

In extending the field of operations, and augmenting the demand for human labour, production would augment with accelerated pace, and the supplies of the necessaries of life would be abundant, and the agriculturist, if it were possible, be transmuted into a contented and thankful being, instead of grumbling at the oppressiveness of rates and taxes, and lamenting the ill-success of his speculations.

Whatever advantages any system of steam cultivation may possess, it is at once evident that with that operation and thrashing the grain, the useful application of the ordinary portable engine, with rope traction ceases. But with the traction engine it is very different, and hence its increased value to the

farmer, who, to use steam successfully, and get the most out of it, must do so, not so much *in addition to*, as a *substitute for*, the employment of horses.

It has been for some time admitted, that the greater portion of the ploughing in this country must be done by the aid of steam, and the only question has been, whether this should be accomplished by means of stationary engines and ropes, or by direct traction.

All the more recent experiments appear to have greatly confirmed the apprehensions originally expressed that the system of stationary engines and ropes, from its complicated nature, involved considerable difficulties; whilst the absence of anything like a corresponding saving in expense seems to lessen the chances of its general adoption; whilst, on the other hand, the many and varied trials to which the direct system of the traction engine and endless railway has been subjected, have tended to prove the simplicity and great facility of its application for all purposes of traction, whether for the plough or on the road; and, on the score of economy, the result is such as to satisfy all those who have hitherto been the most sceptical on the subject.

The useful effect of a horse, or the work done, must evidently depend upon three things—viz., the rate at which he is made to travel; the power of

traction he can exert; and the number of hours he can continue to work daily at that speed; and where there is no fixed condition which determines any one of these, such as a particular load to be moved, or a certain velocity which it is desirable to attain, or a limited time to perform the work in, then the object must be to search for those proportions of the three by which, at the end of the day, the greatest quantity of work shall have been produced.

It appears to be supported by experience, that a horse working continually a certain number of hours per day, will do the most work, when its velocity is equal to half the extreme limit of the velocity of the same horse working the same number of hours unloaded; and that the force of traction corresponding to this speed is equal to half the limit of his power.

For instance, if six hours be the length of a day's work to be decided upon, and if a horse working that time can go six miles per hour unloaded, and therefore producing no useful effect, and supposing the limit of power of the same horse to be equal to 250lbs., it is found that he will do the most work in the same number of hours when drawing a load at the rate of half six, or three miles per hour; and half of 250, or 125lbs. will be the strain corresponding to this speed.

There are, however, many causes to limit the

duration of the day's work of a horse. Tredgold remarks—"The time assigned for the day's work of a horse is usually eight hours; but it is certain, from experience, that some advantage is gained by shortening the hours of labour; and we have observed that a horse is least injured by his labour when his day's work is performed in about six hours; where the same quantity of labour is performed in less than six hours, the over exertion in time shows itself in stiffened joints, while the wearying effects of long continued action become apparent, if the duration of the day's work be prolonged much beyond eight hours. Indeed, under the management of a good driver, a full day's work may be completed in the time before mentioned—six hours—with benefit to the health and vigour of the animal."

The following table, calculated on the supposition that the roads are all good, and the work such as not to cause any immediate injury to the animal, also that the horses are of the average quality, and the force of traction 125 lbs., is given in illustration of the above remarks:—

| Duration of Labour in hours. | Velocity in Miles per hour. | Effect Produced. |
|---|---|---|
| 2 | 5¼ | 578 |
| 3 | 4¼ | 709 |
| 4 | 3⅜ | 813 |
| 5 | 3¼ | 909 |
| 6 | 3 | 1000 |
| 7 | 2¾ | 1063 |
| [illegible] | [illegible] | 1110 |

To attain a higher velocity, it is necessary still further to reduce the load, and the following table is calculated upon the supposition of the strain being only one-half the last, viz., 62½ lbs.; or what is about the average exertion of each horse in a four-horse heavy stage coach.

| Duration of Labour. Hours per day. | Velocity. | Effect Produced. |
|---|---|---|
| 4 | $5\frac{1}{2}$ | 613 |
| 3 | $6\frac{2}{5}$ | 534 |
| 2 | $7\frac{4}{5}$ | 434 |
| 1 | 11 | 307 |

In mails or light coaches where ten, eleven, and even eleven and a-half or twelve miles an hour is attained, the average strain of each horse is barely 40 lbs.; and the effect produced, or value of work done, not much more than one-half the above.

It has been said "It will not be worth while to work steam coaches and engines on Common Roads, because wherever there may exist traffic enough to warrant their use, it will be worth while to lay down Railways."

This may be very true, where means, time, and capital are plentiful, and railways can be made without much inconvenience and expense; but I do maintain, that the opening up of new routes as a *beginning*, and with a view to the *future* construction of a railroad, can, especially in foreign

countries, be much expedited, as also more certainly undertaken, when a certain amount of traffic has been beforehand created and brought on the road by the increased facilities of transport afforded by the use of traction engines for goods, and fast steam coaches or engines for passengers. Besides this, the traction engines afford such vast facilities for transporting the materials used in the construction of the road, at a far cheaper rate than by any other power, that their use for this purpose alone would well warrant their adoption.

It should be borne in mind, that the cost of two miles of railroad would enable sufficient engines and plant for working at *least fifty miles* of road, to be put on; and that after sufficient traffic had been opened up to justify the construction of a railroad, these engines could then be employed in moving the materials required for this purpose, so that in fact they would have more than paid for themselves several times over.

Suppose that, in India for example, 30,000 men have to be marched to a particular district; these require 15,000 camels, averaging £20 each, which creates a locomotive stock costing £300,000, and which will probably have to be *entirely replaced within six months,* at enhanced prices; to say nothing of the loss of baggage, stores, &c., consequent on the

defective means of transit. Camels move at the rate of two-and-a-half miles per hour: it is estimated that they do not average 300 miles in a month. The vast proportions of the territory of the Indian Empire are such, that, combined with the slowness of conveyance, the expense of military movements in distant regions appears very extravagant.

The economy and efficiency of steam traction would produce a revolution of the entire system, and the advantages which would be conferred on the Government, in a military point of view, would be immense. How much more available the forces in that country would be rendered by increasing the facilities of its communications must be evident to every one; and looking at the vast extent of the Eastern Empire, the immense spaces which intervene between its military stations, the number of followers who now attend the march of a single battalion of foot, and the great expense of such marches; the importance of some cheaper, faster, and more efficient means of transporting men, guns, stores, &c., to the scene of duty or action, is at once obvious.

Had these engines been in use during the Sikh war and the late mutiny, a prodigious waste of life and money would have been averted. Troops that were months on the road before they reached their destination, when they arrived worn with sickness

and fatigue, could have been transported some fifty or sixty miles a day, and brought up to their work with unimpaired health and vigour.

By the employment of the traction engine and endless railway, from 1,000 to 1,500 men could easily be transported by five engines and trains, with their arms and equipments, at a rate of four miles an hour, for as many hours in the day or night as it might be necessary to keep on the march; all that would be required would be the arrangement for watering the engines, and the stores of coal or wood at given distances along the line of route.

Not only will these engines be the means of bringing waste land into cultivation by affording a cheap and ready outlet for its produce, and of stimulating its production, but they will enable land at present under cultivation to be cultivated far more perfectly by the new facilities afforded for the transport of lime, manure, and other materials necessary to agricultural improvement.

In India, for example, their use would add stability to the government, and greatly stimulate production of all kinds by affording a cheap and easy means of transport. The chief means of transport in this country, where water carriage is not available, consists of hackerys, or native carts, camels, and bullocks.

Reckoning a hackery to carry 10 maunds, which at 82lbs. to the maund gives us 820lbs. as the load—six camels or twelve bullocks to carry one ton, and a coolie as equal to carry 100lbs., we have a tolerable idea of the facilities of transport such a system affords.

Such have been found the difficulties of transport in that country, that there often has been a famine in one part of the country—when mothers, even for a mouthful of food, have been driven to sell their children—and unbounded plenty in another place not many miles distant. In no country is there such an accumulation of the materials of wealth which need only the addition of facility of transport to bring them into profitable combination, and such is the difficulty caused by the want of a cheap means of transport, that these high gifts are turned into barrenness, and commerce reduced to its lowest ebb.

For instance, the cotton of Nagpore and Amrowty, which is brought for sale to Mirzapore, a distance of 500 miles, is transported the greater part of the distance upon oxen, which carry 160lbs. each, and travel on the average seven miles a day! The cost of conveying 160lbs., 100 miles in this manner, is about 5s.; and should rain occur in the interval, the

cotton is saturated with wet and becomes too heavy for the oxen to carry; the men and cattle sink in the soft earth of the unmetalled tracks which perform the duty of roads, and both merchant and carrier are ruined.

Again, the large quantities of wheat which are annually shipped from Odessa come from a distance of 200 miles, some of it 250 miles; and in years when the demand is very great, a portion is brought even a distance of 400. This wheat is brought in small waggons, drawn by two bullocks, and the number arriving at Odessa in one day has sometimes amounted to 500 or 600, and in several instances to 1,000.

Each of these waggons convey eight sacks of wheat, and the whole load is three quarters and a half, weighing about 1,700lbs. They were dragged along at the rate of about ten miles a day! and though the cattle are grazed, free of expense, on the pasture land on the way, except near the steppes, where, from May to July—the greatest periods of shipment—there are no vestiges of vegetation, the expense is still so considerable that it has often been found to amount, when the prices have been low, to as much, and in some instances to even more, than the load could sell for at Odessa; and that, too,

although the value of a day's labour for a man and two bullocks is only sixpence in Podolia, the province from which most of the wheat is brought.

Of the Indian railroads, it has been remarked in *The Friend of India*, "that as yet they are only single lines, without even roads as feeders; that they have not reached their great termini, but each ends in a swamp or a village; that their fares for third class passengers and for goods are disproportionately high, when the overland traffic, the province of the hills and well-watered valleys are borne along between Madras and Beypore; when Central India and the assigned districts of Hyderabad pour their vast cotton wealth into Bombay; when the goods of Manchester are bound into the interior, and the riches of the doubs and deltas of the Indus and the Ganges, and the tea of the Himalaya slopes are carried down to Kurrachee and Calcutta; when the dense population of the vallies, ever on the move, is attracted by fares lower than those of their own boats, Indian railways will yield almost fabulous dividends."

The *Engineer*, of July 6th, in an able article on "Desiderata in Engineering Practice," says, after having enumerated several, "The fourth desideratum is the general substitution of steam traction for horse power on common roads for the haulage of

merchandise. It has been satisfactorily proved that steam tractive power can be provided *at half the cost of horses, including all charges,* and moving at the same speed.

"The cost of horse power, we believe, varies from sixpence to a shilling per ton carried per mile; whilst steam tractive power costs threepence to sixpence per ton per mile. We have coal mines that will last for hundreds of years, and supply all the fuel and steam we want; but we are in need of all the corn we can save from horse maintenance. The so-called *destruction of roads, frightening of horses, and steam, and smoke nuisance, are bugbears—they can be prevented.*"

## STEAM ON COMMON ROADS.

The advantages to be gained by the substitution of the power of steam for horses, appears to have been appreciated and understood above one hundred years ago; and so early as the year 1759, Dr. Robinson, subsequently Professor of Natural Philosophy in the University of Edinburgh, then a student at Glasgow, threw out some idea of applying the power of the steam engine to the moving of wheel carriages. The earliest account I have been able to find of the practical application of this power to common roads, is that of a locomotive carriage invented by a Frenchman of the name of Cugnot, who completed one in the year 1769.

I am enabled, by the politeness of Wm. P. Marshall, Esq., Secretary of the Institution of Mechanical Engineers, to give the following description and sketches of it; and so curious is the account, that I have preferred giving the entire paper, which was read at the Institution of Mechanical Engineers by E. A. Cowper, Esq., C. E., and runs as follows:—

"The object of the present paper is to put the members of this Institution in possession of certain information, which was obtained by the writer, and your secretary, when in Paris, in reference to a locomotive steam engine for common roads, which they saw in the 'Conservatoire des Arts et Metiers.'

"Attention was first drawn to the subject by a model of a locomotive on three wheels, placed in a glass-case in the "Conservatoire;" and on making diligent enquiries, it appears that the actual engine itself was preserved in an old church that had been appropriated for the reception of various kinds of interesting machines, within the bounds of the 'Conservatoire.'

"Permission to view the engine having been obtained through the kindness of the officer of the Institution, the engine was examined carefully, and general dimensions were taken, and a most interesting sight it was, to see the actual first machine that man had made to run alone by steam. It was a most creditable piece of work, considering when it was made, and would no doubt have caused a much greater sensation in the world than it did, had it not met with a serious accident after it had had two or three little walks only.

"The officer who showed the engine explained that, as it was passing along a street, near where the

Madeleine now stands, in turning a corner, it overbalanced itself, and fell over with a crash; and, unfortunately, instead of being allowed to get the better of the bruise, and have another trial, it was at once locked up, to keep it out of harm.

"The following particulars have been translated from the French description, obligingly furnished to the writer by his friend, M. Armengaud, Professor at the "Conservatoire des Arts et Metiers."

"The accompany drawings, Figs. 1, 2, 3, and 4, have been made by your secretary from the drawing kindly sent by M. Armengaud.

"It appears from documents collected by M. Morin, that a native a Lorraine, in France, named Cugnot, is entitled to the credit of having first constructed a carriage whose wheels were propelled by steam; and that, in 1769, he made a locomotive, on three wheels, to run on common roads, which was put in motion by a steam engine composed of two single-acting cylinders, whose pistons acted alternately on the single front wheel. Nicholas Joseph Cugnot, whose name has been hitherto overlooked in the history of the locomotive steam engine, was born at Void, in Lorraine, on 26th February, 1729, and died at Paris in 1804.

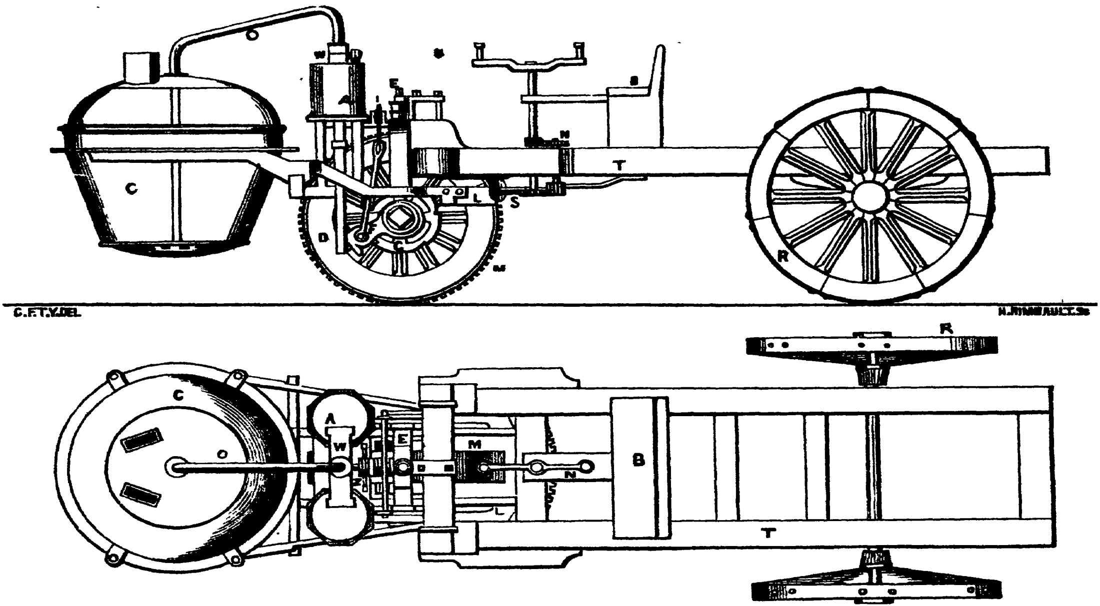
"In the trials of Cugnot's machine, which were made at the Arsenal, in the presence of the Duke de

Choiseul, then Minister of War, General Gribeauval, First Inspector-general of Artillery, and other eminent persons, the new vehicle, loaded with four persons, could not travel faster than two-and-a-quarter miles per hour; and the size of the boiler not being sufficient, it would not continue at work longer than twelve or fifteen minutes; it was then necessary to wait until the steam had again risen to a sufficient pressure before it could proceed further.

"In 1770, Cugnot constructed a new machine, which gave more satisfactory results. The trials made by order of the Duke de Choiseul were, however, abandoned. The employment of steam engines in the place of animals to convey merchandise and passengers, could not become a practically successful application, without the aid of the iron railways of England; and the difficulty of managing the machine on common roads stopped the invention of locomotive steam engines in France, and the efforts of Cugnot.

"Whilst the first machine of Cugnot was in course of construction, in 1769, a Swiss officer, named Planta, presented to the Duke de Choiseul a similar project; but perceiving that Cugnot's machine was preferable to his own, he did not proceed any further with it.

The following is a description of the machine:—




CUGNOT, 1769.—Fig. 1, Elevation; and Fig. 2, Plan.

Fig. 1, is a side elevation; Fig. 2, a plan; Fig. 3, a transverse section; and Fig. 4, a longitudinal section of the front portion.

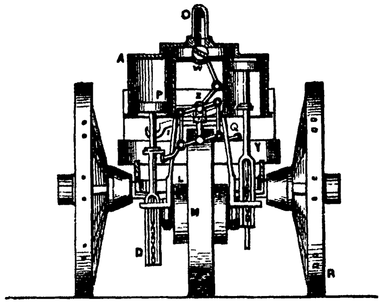


Fig. 3.

"The machine is composed of two parts; the front one (in place of the horse) being supported by a single driving wheel M; these two parts are united by a moveable pin E, and a toothed sector S, fixed on the framing LL of the front part.

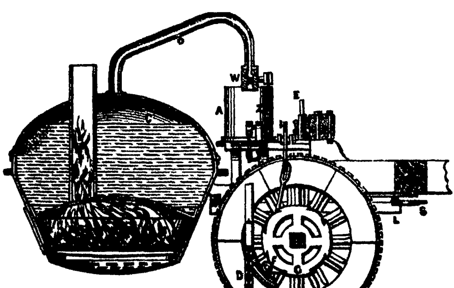


Fig. 4.

"The hind part T is merely a carriage on two wheels R.R, intended to convey the load, and furnished in front with a seat B for the conductor.

"The fore part carries the copper boiler C, having a furnace inside, provided with two small chimneys; the two single acting brass steam cylinders A A communicating with the boiler by the pipe O, and the machinery for communicating the motion of the pistons to the driving wheel M.

"When one of the pistons descends, the piston rod O draws with it the crank F, the catch of which causes the driving wheel to make a quarter of a revolution by means of the ratchet wheel G, which is fixed on the axle of the driving wheel; at the same time the chain H, fixed to the crank on the same side, descends also and moves the lever I, the opposite end of which is raised, and restores the second piston to its original position at the top of the cylinder by the interposition of a second chain and crank.

"The piston rod of the descending piston, by means of a catch Y, causes the levers Q Q to turn round, moving the levers Z Z at the same time, and the chain fixed to them turns the four-way cock W, and opens the second cylinder to the steam, and the first cylinder to the atmosphere. The second piston then descends in its turn, causing the driving wheel to

make another quarter revolution, and restores the first piston to its original position; and thus the process is repeated.

"In order to allowof changing the direction of the motion, and make the vehicle run backwards, the the catch of the crank F was arranged in such a manner that it could at pleasure be made to act either above or below; in order to obtain a backward motion, it was merely necessary to make it act on the upper side (changing the position of the spring which pressed upon it); then when the piston drove it down, it slipped over the rachet wheel, and on the other hand the catch in the opposite side was raised by the lever, and turned the wheel a quarter revolution in the direction contrary to the original motion.

"The conductor could further turn the carriage at an angle of from 15° to 20°, by means of a set of cog wheels N N, the last of which worked the toothed sector S, and the first of which was turned by a spindle furnished at the top with a double handle in front of the seat B.

"It will, no doubt, be in the recollection of most of the members, that the earliest recorded date of any other locomotive was that of Murdoch, in 1784, being fifteen years later than Cugnot's engine: this

engine was shown at work at a former meeting of this Institution.

"Various persons have suggested the moving vehicles by steam, but none, it appears, so early as Cugnot, who actually ran an engine on land. Papin, certainly, in his work published at Capel, in 1699, suggested the use of ratchets to convert the motion of a piston into a circular motion, but it does not appear that he had any idea of a locomotive.

"After the date of Cugnot's engine, there are several persons whose names should be mentioned as having suggested the use of steam for locomotion, viz., Watt, in 1784; Oliver Evans, in 1786; Professor Robinson, in 1795; and lastly, Trevithick and Vivian, in 1804, who not only ran a locomotive steam engine, but laid down *rails* for it to run on, at Merthyr Tydvil, in South Wales; and from this time the improvements introduced in locomotives and railways have been almost incessant, until we have now good smooth roads, and locomotives which run much faster than the wind."

The chairman observed that the paper was an interesting record of the first attempt to apply steam to locomotion, and it appeared that they had not been hitherto giving the credit where it was really due. It was highly interesting and instructive to

look back, in tracing the progress of invention, to see how much the ingenuity of man had been directed to do something that was mistaken in its object. Generally the first attempts at invention commenced with a complicated machine, and the progress of subsequent improvements was gradually to simplify "a vast amount of ingenuity having been expended in overcoming difficulties which need not have been encountered."

At page 249 of the catalogue of the "Conservatoire dcs Arts et Metiers," published in 1859, I find the following:—"25. Steam carriage for ordinary roads, by Cugnot, Military Engineer.

"According to a notice by Colonel Morin on this coach (Comptes-rendus de l'Académie des Sciences, 14th April, 1851, et les pieces authentiques qui y sont insérées), Cugnot had in 1769 conceived and made a similar coach to this; at the same time that a Swiss officer, named Planta, was occupied in the solution of the same problem.

"Planta was commissioned by General Gribeauval to examine Cugnot's coach; and having found it on all points preferable to his own, the Minister Choiseul ordered Cugnot to complete the coach he had begun, at the cost of the state.

"When tried in the presence of the Minister, of General Gribeauval, and a great number of other

spectators, it attained, on the level, with four persons on it, a speed of from 1800 to 2000 toises an hour; but the size of the boilers not having been properly proportioned to the size of the cylinders, the coach was not able to travel more than from ten to fifteen minutes without stopping nearly as long, to allow the steam to get up again. The furnace, also, was badly made, and the boiler seemed to be too weak.

"This trial having been throughout considered sufficiently encouraging, Cugnot received orders to construct a new coach, to be proportioned in such a manner that when loaded with a weight of from 8 to 10,000 lbs., it should be able to maintain a speed of about 1800 toises an hour on the level. This carriage finished, about the end of 1770, at a cost of about 20,000 livres, is that which is seen in the large church of the Conservatoire. She was built by Brezin, but it does not appear that she ever underwent a trial."

In the year 1772, Oliver Evans, an ingenious American wheelwright, employed much time in endeavouring to obtain some better means of moving wheel carriages than horse power, and was at last convinced, from experiments, of its adaptability for that purpose, in spite of an immense amount of ridicule.

In 1786 he petitioned the legislature of Philadel-

phia for the exclusive right to use his improvements in flour mills and steam waggons in that State. He was listened to patiently when describing the mill improvements, but was thought mad when he spoke of the waggons! In 1787 he got the act for his mill work, but nothing was said about the waggons.

In the same year, the legislature of Maryland gave him the exclusive right to use his waggons for fourteen years from that time, on the ground that it would injure no one. So convinced was he of its perfect practicability and immense advantages, that he prophetically remarked, "I verily believe that the time will come when carriages propelled by steam will be in general use, as well for the transportation of passengers as goods, travelling at the rate of fifteen miles an hour, or three hundred miles a day!" He also remarks, "Why may not the present generation, who have already good turnpike roads, make the experiment of using steam carriages upon them? They will assuredly effect the movement of heavy burdens with a slow motion, at two and a-half miles an hour, and as their progress need not be interrupted, they may travel fifty or sixty miles in the twenty-four hours."

In the year 1804, having built a large flat or lighter, by order of the Board of Health of the city

of Philadelphia, to be used in cleansing the docks, and fitted on board a small engine of 5-horse power, to lift the mud into lighters, he determined to convert this huge mass into a locomotive! When it was finished, he put some wooden wheels under it, and though it weighed nearly as much as two hundred barrels of flour, and every thing was exceedingly rough, and the friction, as a necessary consequence, very great: "yet with this small engine I transported my great burthen to the Schuylkill with ease." He then tells us that "some wise men undertook to ridicule my experiment of propelling this great weight on land, because the motion was too slow to be useful; I silenced them by answering, that I would make a carriage to be propelled by steam, for a bet of three hundred dollars, to run upon a level road against the swiftest horse they could produce. I was then as confident as I am now, that such a velocity could be given to carriages."

It will be seen further on how wonderfully all Evan's remarks have been carried out in practice by Gurney, Gordon, Hancock, &c. He also remarks, "*Having no doubt of the great utility of steam carriages on turnpike roads, with proper arrangements for supplying them with water and fuel,* I submitted to the consideration of the Lancaster Turnpike Company a statement of the costs and profits of a steam

carriage, to carry one hundred barrels of flour, fifty miles in twenty-four hours; tending to show, that *one such steam carriage would make more net profits than ten waggons drawn by five horses each, on a good turnpike road.*" My estimate of the cost of working a steam traction engine for hauling goods on the turnpike road, *the results of constant work,* will corroborate his remarks.

In the year 1784 James Watt took out a patent, amongst other improvements of the steam engine, for a mode of applying it to wheel carriages, but there is no record of his ever having attempted to carry it out in practice.

In his patent granted to him in 1784, he gives an account of the adaptation of his mechanism to the propulsion of land carriages. The boiler of this apparatus he proposed should be made of *wooden staves* joined together and fastened with iron hoops like a cask. The furnace was to be made of iron, and placed inside the boiler, so as to be surrounded on every side with water. The boiler was to be placed on a carriage, the wheels of which were to receive their motion from a piston working in a cylinder, the reciprocating motion being converted into a rotary one, by toothed wheels, revolving with a sun and planet motion, and producing the required velocity by a common series of wheels and pinions.

By means of two systems of wheel-work, differing in their proportion, he proposed to adapt the power of the machine to the varied resistance it might have to overcome from the state of the road. A carriage for two persons might, he thought, be moved with a cylinder of seven inches in diameter, when the piston had a one foot stroke, and made sixty strokes a minute! Watt, however, never made a steam carriage. It is well known that up to the period of his death, he retained the most rooted prejudices against the use of high steam; indeed, he says himself—"I soon relinquished the idea of constructing an engine on this principle, from being sensible it would be liable to some of the objections against Savary's engine, viz., the danger of bursting, and also that a great part of the power of the steam would be lost, because no vacuum was present to assist the descent of the piston."

It should be remembered that in the earlier days of Watt with low steam, the tops of the boilers were frequently constructed of *sheet lead*, and in those days, when the art of working in iron plate was less understood, and less common than it is now, such sheet lead might often be found forming the cover of the antiquated haystack boiler of the period.

In the year 1784–5 Murdoch constructed the model of a steam carriage whilst residing at Red-

ruth, in Cornwall, which ran upon the road. The boiler is of copper; the flue passing obliquely through it, and the heat is obtained from a spirit lamp. The cylinder has a diameter of only three-quarters of an inch, with a stroke of two inches, turning a crank in the axle of the larger wheels, which are nine inches and a-half in diameter. This little locomotive, standing no higher than fifteen

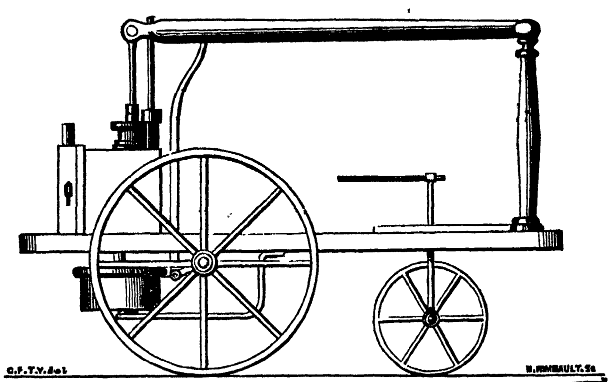


Fig. 5.

inches above the ground, could run at a speed of six or eight miles an hour.

It had three wheels, with the connecting rods working off a beam, whose fulcrum was at the end instead of being, as is usual, at or about the middle. Fig. 5 is a correct engraving of it. This small model is still in existence; it was exhibited in 1851,

at the Great Exhibition, and still more recently at the conversazione of the Royal Society, and remains, I understand, under the care of Mr. Bennett Woodcroft.

In the year 1786 or 1787 William Symington, for whom there has been made reasonable claim to be considered as the original inventor of the steam boat, and whose original engine may be seen in the Patents Museum, at South Kensington, where it is carefully preserved, constructed a working model of a steam carriage, which he submitted to the inspection of the professors, and other scientific gentlemen

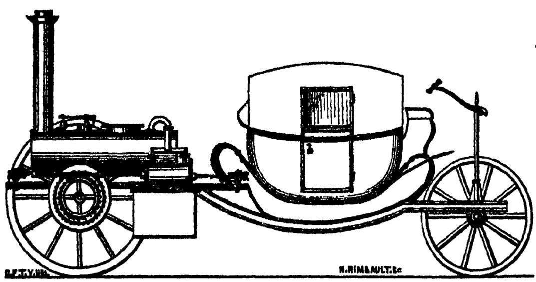


Fig. 6.

of Edinburgh. He seems to have designed the use of a condensing, or low pressure engine, with one cylinder for that purpose.

So efficiently did this model (Fig. 6) work, and so practicable did the propulsion of wheeled carriages by steam appear, that he was urged to carry this

machine into practice; but so great were the difficulties to be overcome in this, that he conscientiously stated his scruples to those anxious to aid him in the matter, advising them not to proceed with it. The engraving shows the condenser and the ratchet motion similar to that used in his marine engine.

In the year 1802, Messrs. Trevithick and Vivian

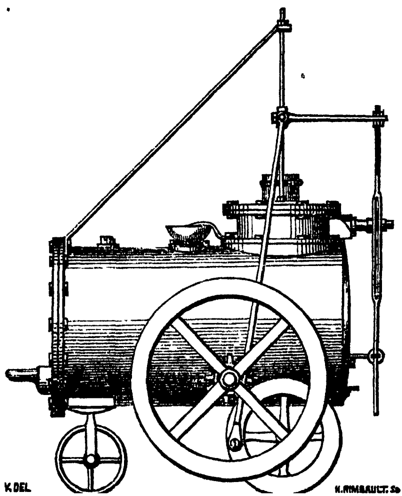



Fig. 7.

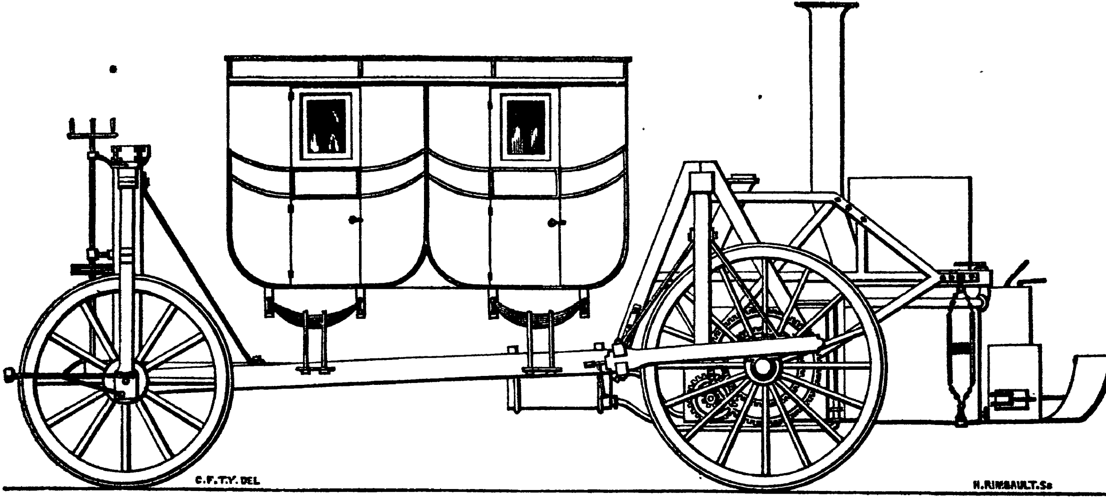
invented a very compact and snug high pressure engine and boiler, which were connected together, and so arranged as to make one machine: this may be considered the type of engine whence our present locomotive is derived. A small working model engine of a locomotive on this plan (Fig. 7), may

be seen in the Patents Museum, South Kensington. The label attached to it has the following inscription:—"Locomotive Engine, made by the late Richard Trevithick, about the year 1802. Letters Patent, No. 2,599—1802;" and it stands complete —ready for work, with the heater in the furnace, and valve motion, &c., complete.

It is on three wheels, like that of Murdoch's, has a fly wheel to assist in carrying the engine over the dead point at each stroke, which is driven by the teeth on one half of the width of the driving-wheel, taking into a pinion on its shaft, and is a curious and interesting relic of the earlier days of steam locomotion.

This engine was not put into operation until 1805, when Mr. Trevithick had an opportunity of proving its utility upon the Merthyr Tydvil Railroad, South Wales. It had a cylinder 8 inches in diameter, and a stroke of 4 feet 6 inches in length, and drew after it upon the railroad as many carriages as carried ten tons of bar iron, from a distance of nine miles, which it performed without any supply of water to that contained in the boiler at the time of setting out, travelling at the rate of five miles an hour.

It appears that the more general adoption of this machine was prevented by a fear that the wheels would not adhere sufficiently to the surface over which they passed, but that they would slip round




GRIFFITHS, 1821.—Fig. 8, Elevation.

without producing locomotion when any considerable load was attached to the machine.

The carriage which Mr. Trevithick constructed in 1804 had only one cylinder, which by the motion of the carriage was enabled to get over the centres, but we are not told how he managed if she hung on them as in starting. He tried this engine for some time on the ground where Euston Square now stands, and also in some other places, but either from the bad state of the roads, or some other reason, he gave up any further attempts at road locomotion, and turned his attention to railroads, as the best field for their introduction.

The first steam coach constructed in this country *expressly for the conveyance of passengers on common roads,* was that by Julius Griffiths, of Brompton, Middlesex, who, in 1821, patented and *made* a steam coach to run on common roads. It was constructed by the celebrated Joseph Bramah (the "Patent Brahmin" of Sam Weller, in "Pickwick"), and was intended to work on good turnpike roads. This carriage (Fig. 8), was propelled by two steam cylinders, which were supplied with steam by a boiler, consisting of several horizontal tiers of tubes, the ends of which passed through iron plates, forming the sides of the heating chamber, and then returned again across the same. The uppermost rows of tubes

acted as steam reservoirs, receiving the waste heat as it passed to the chimney, thereby increasing the elastic force of the steam before it proceeds along the steam pipe to the engines, whence, after moving the pistons, it was conducted to the condenser, which consisted of a number of flattened thin metal tubes exposed to the cooling influence of the air. The water was supplied to the boiler by a small feed pump, which forced it into the lowest rows of tubes, whence it ascended into each higher row until it was turned into steam, and received in the higher tubes ready for supplying the cylinders.

The power of the engines was communicated from the piston rods to the driving wheels by means of sweep rods, the lower ends of which were provided with driving pinions and detents, which operated upon toothed gear fixed to the hind carriage wheel axle. The object of this mechanism was to keep the driving pinions always in gear with the toothed wheels, however the engine and other machinery might vibrate, or the wheels be jolted upon uneven ground; and, in order that the engines and steam apparatus might not suffer from the concussions of the latter, they were suspended by slings to a strong iron framing; and to give the suspending chains some degree of elasticity, stout helical springs were introduced between them.

The guiding of this carriage was effected by means of levers, which turned the axle of the front wheels. The axles were supported in a vertical frame, made to turn horizontally by means of a guide wheel on the top of a spindle, the lower extremity of which carried a pinion, which took into an internal toothed wheel. The spring supporting the boiler, which acts by the compression of a spiral spring has lately been repatented, and is proposed to be used for various purposes, such as draw springs, &c. Many experiments were made with this carriage in Messrs. Bramah's yard, where it remained for several years. The experiments proved unsuccessful, but had the boiler been of such a kind as to generate *regularly* the required quantity of steam, a very efficient carriage would, no doubt, have been the consequence.

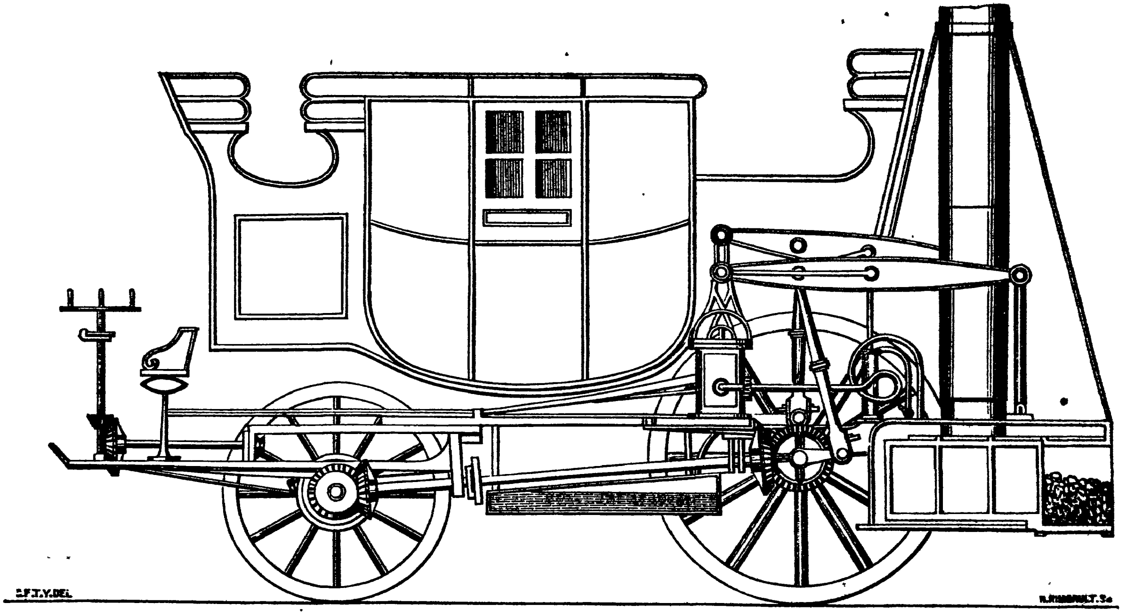
An engraving of this steam carriage has been given, not for any intrinsic merit it possesses, but because it was the first steam coach constructed in this country to run with passengers on common roads; for though Trevithick had constructed a locomotive in 1804, we find that it was considered by him more applicable to railroads than common roads, and that he turned his attention to its introduction for this purpose.

In 1822 Mr. David Gordon patented the engine

described under "Distributed Weight," but I am not aware if ever one was constructed.

During this year Mr. Goldsworthy Gurney stated, in his public lectures on the elements of chemical science, that "elementary power was capable of being applied to propel carriages along common roads with great political advantage, and that the floating knowledge of the day placed the object within our reach." Having tried a series of experiments with ammoniacal gas, he found it gave a motive power capable of being worked with the ordinary apparatus of a steam engine, and he constructed a little locomotive engine, which acted by this power with great regularity. This experimental apparatus was eventually made the basis of a steam engine, with which his first experiments in locomotion on common roads were made.

In 1824 Mr. David Gordon took out a patent for an arrangement of machinery, by which an action similar to horses' feet could be obtained. This was effected by six hollow iron legs, at the lower extremity of each of which there were feet to push upon the ground, so that when the legs pushed out behind, the carriage was pushed forward. To prevent the feet bounding off the road without taking hold and pushing the carriage onward, it was found



Burstall & Hill, 1824.—Fig. 9.

necessary to use lifting rods. These rods were hollow, and had a small solid rod in their interior, which was pressed out by a spiral spring in the hollow rod; so that these connecting rods (the lifting apparatus) were lengthened when the feet got into a hollow, and shortened, if the feet got on a stone, or other little eminence between the track of the wheels.

This plan of propulsion is evidently a modification of Brunton's, patented about 1812; and the same principle was revived, patented, used, and abandoned by Gurney some time afterwards, and others, as may be seen further on.

In 1824 Messrs Burstall and Hill, of Edinburgh and London, patented and made a steam coach, Fig. 9. Numerous experiments were made with it in London at various times, the intervals being occupied in making a variety of alterations. The utmost speed attained is stated to have been from three to four miles an hour, which was performed in an enclosed piece of ground. A great deal of time was lost, and expense incurred, by the repeated failure of the boilers.

In 1824 and 1825 Mr. W. H. James, of London, patented some very ingenious arrangements of the working parts of a steam carriage, such as enabling them to be hung on springs, allowing the carriage to

turn without putting either wheel out of gear, and some other ingenious contrivances.

In 1825 Mr. Goldsworthy Gurney patented and produced a steam carriage, impelled by legs, in a similar manner to that of Mr. David Gordon, before described. In his first experiment with this engine he ascended Windmill Hill, near Kilburn, but being of opinion, with many others at that time, that the friction of the wheel was not sufficient to impel the carriage up acclivities, he used the legs or propellers. This application of levers was found inconvenient and heavy; so, after a good deal of study, a combination of these levers and wheels was resorted to, it having also been found by Mr. Gordon "that the propelling feet did more injury to the road than the propelling wheel." It was so arranged that when the wheels should slip the levers should come into action. A trip by steam between London and Edgware (nine miles and a-half from Mr. Gurney's factory) was effected by this arrangement; and the levers were subsequently abandoned, the wheel being found not only to be sufficient for propelling the carriage, but also to allow of considerable traction power.

In 1825 a patent was obtained by the Messrs. Seaward, engineers, London, for a steam carriage, to be propelled by means of a wheel or wheels, mounted on a swing frame, so as to accommodate themselves

to the roughness or unevenness of the ground, but no part of the weight of the engine was carried by these wheels. The faces or surfaces of these wheels where they touched the ground, had projecting teeth or indented surfaces to give them a "hold" on the ground, so as to "prevent them from slipping," a plan lately revived and patented by several persons, who affirm that such a system does not "injure the roads," &c., but as a very efficient "rotary digging machine," is *identically similar in principle*, I am very sure there cannot be much doubt on that point.

In 1826, Mr. Samuel Brown fitted up a carriage so as to be propelled by his Patent Gas Vacuum Engine, and ascended Shooters Hill to the satisfaction of numerous spectators; but the great expense of working such an engine caused it to be laid aside.

In the same year Messrs. Hill and Burstall obtained a patent for improvements in steam carriages, and in the following year completed one which was exhibited at Leith and Edinburgh, and in front of the Bethlehem Hospital in London, but it was soon abandoned. I have not been able to find any further particulars of this engine.

Mr. Goldsworthy Gurney also obtained another patent this year, for "improvements in steam

carriages." With one of his carriages he made several trips during this year, going up Highgate Hill, Stanmore Hill, and Brockley Hill, and running to Edgware and other places, in all of which he was very successful.

In the year 1827 Mr. Burstall, who had been engaged with Mr. Hill, of London, in constructing steam carriages, made a small working model of an improved coach on the scale of three inches to the foot. This model was exhibited at work in Edinburgh and other places, where it travelled round a circle 17 feet in diameter, on an uneven deal floor, with a speed equal to between 7 and 8 miles per hour. A deal platform 18 feet long, rising 1 foot at the end, or 1 in 18 was fixed, which the carriage ran up with ease and rapidity. On the outside of the circle was a deal bank, which rose 5 in 25 on the cross section, to show how little lying on one side would affect its safety, owing to the centre of gravity being placed so near to the ground. The model was subjected to the roughest usage, by running it over tools of various kinds which were placed in its way; and it was stated that it had run in the space of eight days 250 miles without any fresh packing or repair.

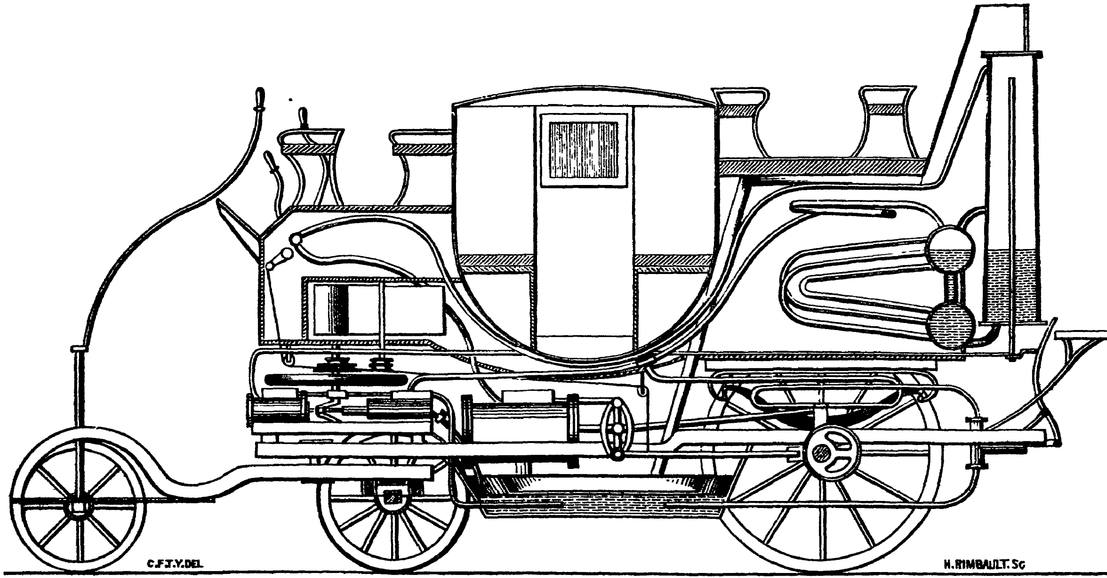
Towards the end of this year Mr. Gurney obtained another patent for improvements in locomotive en-

gines and the apparatus connected therewith. His steam carriage was, in external appearance, very similar to a stage coach, and the boiler was placed in the hind boot. This carriage was propelled by the adhesion of one wheel, though means were provided for driving with both if required. He made many trips with this carriage; running to Barnet, and up all the hills on the road, using only one wheel as a propeller; and it was run experimentally for eighteen months in the neighbourhood of London. He also went with it to Bath, and over all the hills between Cranford Bridge and Bath, and returned driving from one wheel only, the clutch or carrier having broken at the first outset, and could not be repaired until their return; the carriage was also slightly injured at Melksham, in consequence of a riot there; and after waiting about two days at Bath, to get the damage repaired, they returned from Melksham to Cranford Bridge, a distance of eighty-four miles in ten hours, including stoppages.

An immense deal of praise and commendation has been very needlessly bestowed on the design of Mr. Gurney's engine, just described. Dr. Lardner especially, in his "Steam Engine," seventh edition, published in 1840, becomes quite enthusiastic in his praise of it. He also gives the credit of the "contrivance of levers and propellers which acted on the

ground in a manner somewhat resembling the feet of horses to drive the carriage forward" entirely to Mr. Gurney, though seeing that Mr. David Gordon had patented these same propellers *many months before,* it is difficult to conceive how he can have the credit assigned to him. The doctor also remarks, in the same edition, that Mr. Gurney's name stands "first, &c., in the history of the application of steam to propelling carriages on turnpike roads." Having seen that Griffiths was the first in this country to construct a steam coach *expressly* for this purpose, it is at once evident how far the doctor's statement is correct.

I must confess, after a careful examination of the numerous engravings of Mr. Gurney's steam coaches, that I cannot see anything in the design and construction of his carriages deserving the least commendation, except his destroying the noise of the waste steam, and his plan for warming the feed water. That I am not prejudiced in my opinion may be easily seen by my mechanical readers, in five minutes study of the "Vertical Section of Mr. Gurney's Improved Steam Coach, 1828," Fig. 10, copied from the drawing at page 542 of "Galloway and Hebert's Treatise on the Steam Engine," published in 1836; and also in "Hebert's Engineers' and Mechanics' Encyclopædia," 1838.




GURNEY, 1828.—Fig. 10, Vertical Section.

The entire absence of anything like a regard for economy of fuel in these engines is most strikingly apparent, and one can hardly conceive how "surface condensation," and "keeping everything cool" by exposure to atmospheric influences, could be better carried out than they are in these engines; to say nothing of the "improvement" in their working, that must be attained by the exposure of all the running parts to the dirt and dust of the roads.

These carriages can in *no way* be compared with those of Hancock, whose plans and arrangements, especially his admirable wheels for these coaches, exhibit an amount of skill and mechanical knowledge that can hardly be surpassed, even at the present day; and with all these facts and other things before them, one feels at a loss to understand why so much exclusive merit should have been awarded to Mr. Gurney, especially when others have been equally, if not more successful, in their practical carrying out of the principle of steam carriages on common roads.

To show the truth of these remarks, I have engraved Fig. 11, which is a view of the interior arrangement of the boiler and engine room of one of Hancock's carriages; and it will compare very favourably with Mr. Gurney's arrangement, as shown in Fig. 9.

By this arrangement of Hancock's, the engines are completely protected from the dirt and dust of the roads; are at all times in sight of the engine-man, and every part is within his reach. The chains allow the full play of the springs, and a vibrating stay from the crank shaft to the axle prevents the

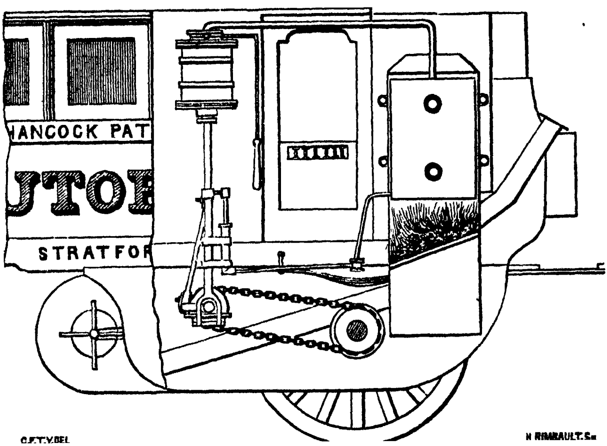



Fig. 11.

pull of the chain or jolt on the road, causing any irregularity in the motion, and thus secures a uniform distance between the axle and crank-shaft.

From the use of a distinct crank shaft the axle which carries the whole weight of engines, carriage passengers, &c., is not only preserved straight, and consequently in the best form to sustain that weight

but is also relieved from the strains it has to bear, when it forms both crank shaft, and axle, and has to propel the carriage and carry the weight as well.

In 1828 Dr. Harland, of Scarborough, patented a steam coach, in which he purposed to employ the system of *condensation* by exposing a large surface to the influence of the atmosphere, into which the waste steam was passed, such as Griffiths had done some years before. The motion of the carriage was obtained by means of a toothed driving wheel on the axle, into which another toothed driving wheel, turned by the engine worked: now as the *top* driving pinion was attached to the body of the carriage, and rose and fell with it, according to the play of the springs, it is very evident that such a carriage would not have run very long, and I do not think he ever constructed an engine on this plan.

On the 5th March, 1829, a four-wheel locomotive carriage, constructed by Sir James Anderson and Mr. W. H. James, in accordance with his patent of 1824–25, and weighing nearly three tons, was started on Epping Forest. It had two cylinders of only three inches and a-half in diameter, and was propelled by the hind wheels. With this apparatus the carriage, loaded with fifteen passengers was propelled several miles on a rough gravelled road across Epping Forest, at a speed varying from twelve to

fifteen miles per hour. The boilers were composed of common welded gas tubes; but the pressure of the steam, 300 lbs. per square inch, opened the seams of some of them, and by putting out the fire of one boiler, reduced the power of the engine; but still it returned home with twenty-four passengers, at the rate of about seven miles an hour.

By the end of the year, fresh boilers with better tubes were put in, and numerous experiments made with the engine. The greatest speed attained upon a level was 3 miles in twelve minutes, or at the rate of 15 miles an hour.

About this time, or perhaps earlier, Mr. Walter Hancock of Stratford, Essex, who had patented a very ingenious and efficient boiler in 1827, constructed a three wheeled coach (Fig 12) to carry four

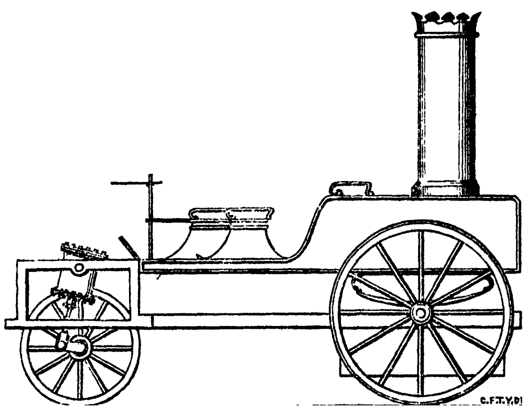


Fig. 12.

passengers, which was propelled by a pair of *oscillating cylinders*, working the *double cranked axle* of the front, or steering wheel. Defective as this first attempt was, the carriage ran many hundred miles in experimental trips from his factory at Stratford, sometimes to Epping Forest, at others to Paddington, and frequently to Whitechapel. On one occasion it ran to Hounslow, and on another to Croydon, and in *every instance* it accomplished the task assigned to it, and returned to Stratford on the same day it had set out.

Subsequently this carriage went from Stratford through Pentonville, to Turnham Green, over Hammersmith Bridge, and thence to Fulham, where it remained several days, and made numerous excursions for the gratification of those who desired to see its performance.

In the year 1830 there were five or six steam coaches in course of construction by Mr. Hancock, Messrs. Ogle and Summers, Sir Charles Dance, &c.; and most of the experiments made with them were attended with most successful results.

In February, 1831, Mr. Hancock commenced running his coach, the "Infant," regularly for hire between Stratford and London, along the common road. Before this Engine was placed on the station, it was tried for several months in every possible way,

and so efficient and satisfactory did these trials prove, that it was taken as a model for all future engines constructed by that gentleman.

The same year Sir Charles Dance started a steam coach to run regularly on the road between Gloucester and Cheltenham, which it did successfully for four months.

Mr. Ward of Glasgow, during this year, made several trips in and about Glasgow, with one of Mr. Gurney's carriages; but the experiments were not quite so satisfactory as the owners could have wished. It appears the carriage had been hastily put together, and shipped off to Leith; and that either in shipping, on the voyage, or unloading, the engines received some injury, which not being perfectly repaired, occasioned the disappointment.

A trip, however, was made with nine passengers in this steam carriage, from Glasgow to Paisley, and back by Renfrew to Glasgow, at the speed of between nine and ten miles per hour.

Sir Charles Dance's carriage, built by Gurney, ran between Gloucester and Cheltenham four times a day, regularly for four months, from the 21st of February to the 22nd of June, 1831, during which time it carried nearly 3,000 persons, and travelled 3,564 miles. They performed the distance (nine miles) in fifty-five minutes on an average, and

frequently in forty-five. They had delays sometimes, owing to the leakage of the tubes or pipes forming the boiler, but no injury or accident occurred to any one, nor were the engines ever out of order. On the 23rd of June they broke the hind axle in running through heaps of stone, which had been purposely laid across the road in order to drive them off; but the engine went, with seventeen passengers, the trip to Cheltenham, taking, however, eighty minutes to do the trip. In consequence of this, and the passing through Parliament of a vast number of Turnpike Bills, which allowed of prohibitory tolls being levied on the use of steam carriages, he gave up in disgust, and took his carriage off the road, after having run 315 journeys most successfully.

In 1831 Messrs. Ogle and Summers built a steam carriage, which, it appears, attained a very high rate of speed, Mr. Ogle having stated, in his evidence before the Committee of the House of Commons, that "the greatest velocity he obtained over rather a wet road, with patches of gravel upon it, was between 32 and 35 miles an hour!" It appears that they did run over a distance of about four and a half miles at a very great speed, and also went "from the turnpike gate at Southampton to the four-mile stone on the London road, a continued elevation,

with one slight descent, at a rate of 24½ miles an hour, loaded with people."

They employed a pressure of 250 lbs. steam in their boiler, and the carriage had run about 800 miles without the slightest accident. Mr. Summers stated, in his evidence before the same Committee, that their former carriage ran from Cable Street, Wellclose-square, to within two miles and a half of Basingstoke, where the crank shaft broke, and they were obliged to put it into a barge and send it back to London. This same engine had previously run in various directions about the streets and outskirts of London. With one of their improved carriages they went from Southampton to Birmingham, Liverpool, and London, with the greatest success.

From the long-continued success of Mr. Hancock in running his steam carriages on the roads and streets of the metropolis, the following short sketch of his proceedings has been arranged in the form of a consecutive history, so that the narrative is not interrupted by the notices of other carriages, which, however, follow in due course after the conclusion of this.

In February, 1832, the "Infant" was run for several days by Mr. Hancock from Paddington to the City, with the greatest success, with the view

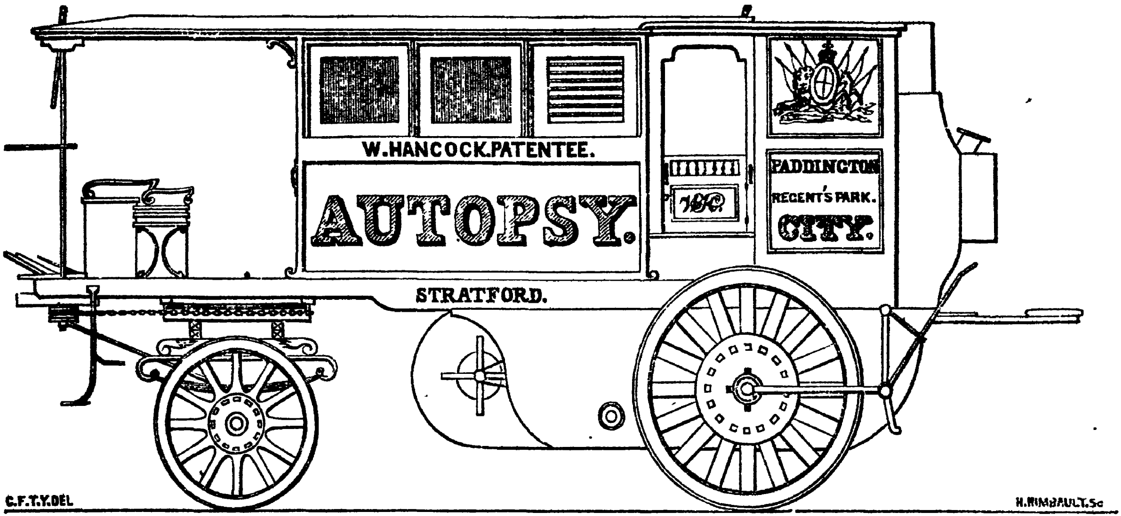
of establishing a line of steam coaches on that road. In that year a carriage called the "Era," was built for the "London and Greenwich Steam Carriage Company," and was intended to run between London and Greenwich. This carriage made a journey to Windsor shortly after its completion, and a good many trial trips, but the company did not get along so well as they desired.

On the 31st of October, 1832, the "Infant" took a trip to Brighton; Mr. Hancock was accompanied by Mr. Alexander Gordon, and numerous other scientific gentlemen, eleven in all, and started from Stratford to the Blackfriars Road, where it remained until the next morning. They started at the rate of nine miles an hour, and kept up this speed until they arrived at Redhill, which they ascended at the rate of five to six miles an hour. At Hazledean they were obliged to stop for the night, in consequence of being unable to procure any coke, having steamed thirty-eight miles under great disadvantages.

Next morning they started in good style, speed varying from nine to eleven miles per hour, and ran safely to Brighton, where they went round the Grand Parade and Waterloo Place, to the surprise and satisfaction of a large concourse of spectators. They then took up four additional passengers, two of whom were ladies, and started on their return.

One mile was done in three minutes fifty-eight seconds—above fifteen miles an hour; and they reached Aldbourne, a distance of ten miles in fifty-five minutes, including stoppages for water; but, from want of coke, they could only get as far as Hazledean, fifteen miles and a-half from Brighton. Here they remained until next day, when, having obtained the necessary supply of coke, they started for London. The great drawback on this trip was the want of a supply of coke at the proper places, a difficulty which would not exist where regular journies were made. We found on the trip to Liverpool great difficulty and bother from not knowing where to get water, the road being strange, which made us more careful to fill up the tank much oftener than there was any necessity for, had we known the road beforehand, and consequently made our journey some hours longer than it need have been.

This engine was again run to Brighton in the month following. They started from Stratford a few minutes before six in the morning, and arrived at Brighton at 3.40, having run at the rate of twelve miles per hour. The whole distance from Stratford was fifty-seven miles. Two hours and-a-half were lost in dining and breakfasting on the road, and in taking in coke and water; but the actual time in running was less than six hours.




HANCOCK, 1833.—Fig. 13, Elevation.

Next day they started for London, having made two or three trips through the streets of Brighton; and the first sixteen miles of the journey were performed, including twenty minutes stoppage for coke and water, in one hour and forty minutes.

In the beginning of 1833, the "Enterprise," a new carriage, was started to run for hire on the road between Paddington and the city, where it ran regularly for sixteen days, under the superintendence of Mr. Hancock. This carriage was built for a company, formed for the purpose of working this line of traffic, the fare being one shilling for the trip; and the journey was always done under the hour. In consequence of some differences between Mr. Hancock and the company—in which it appeared, that like most companies, when opposed to individuals, a great deal of unscrupulous conduct was exhibited by them, including the usual amount of mismanagement, &c. &c.,—the relation between him and them came to an end, and the carriage ceased to run.

About the end of the summer of 1833 he completed another steam coach, the "Autopsy" (Fig. 13), and with it performed a journey to Brighton, where he remained two days, during which time the carriage was run through the principal streets and squares of the town. On returning to Stratford he

passed over London Bridge, and through the City, during the middle of the day, proving the ease and facility with which the movements of such a carriage can be accommodated to all the incidents it might be liable, even in the most crowded thoroughfares. He also frequently ran his carriages through the most crowded thoroughfares of the metropolis during the busiest hours of the day, without the slightest accident.

In the month of October in the same year, the "Autopsy" ran for hire between Finsbury Square and Pentonville, and continued to do so daily, without accident or intermission, for nearly four weeks. Having received an order in the spring of 1834 to construct a small steam drag for a gentleman in Vienna, thus preventing his personal attention to the running of the "Autopsy," which hitherto had always been steered by himself, he withdrew his coach from the road; and whilst the drag was being built, he fitted up premises in Windsor Place, City Road, with all the requisite conveniences, for a steam carriage station, such as water, coke, &c.

This drag was completed in July 1834, and underwent a variety of trials previous to its leaving England. On one occasion it took seven passengers, and three attendants on itself, and drew after it a close four-wheel carriage containing six passengers

(seven more than was stipulated for), making a total of sixteen passengers. Thus loaded, it was steered by Mr. Voightlander, the proprietor, through Bow to Homerton, Clapton, Crouch End, and over Stamford Hill to Tottenham; thence through Ball's Pond and Islington to the City Road, the distance altogether being about fourteen miles. The speed at which this trial journey was performed was fourteen miles an hour on the level road, and from eight to nine miles an hour up the hills.

In the month of August, the same year (1834), he completed another carriage, called the "Era," and on the 18th of the same month he recommenced running daily for hire, with his two carriages the "Era" and "Autopsy," between the City, Moorgate, and Paddington, and continued to do so without intermission, except on one or two occasions, till the end of November, keeping his time in starting, &c., with the utmost regularity; and during this period he carried nearly 4000 passengers. The journey to Paddington from Moorfields (five miles) was done in about half-an-hour, including stoppages, a speed excluding stoppages, of twelve miles an hour.

About the end of November he was induced, at the request of some influential gentlemen, to make an arrangement for the conveyance of one of his carriages to Dublin, and in consequence he discon-

tinued running on the Paddington road. The "Era" was the carriage chosen for the trip; and, having been re-embellished, and its name changed to the "Erin," it was shipped on board the *Thames* steam vessel, on the 30th December, 1834, and arrived safely in Dublin on the 6th January, 1835.

As soon as it was landed, it was put on the Howth Road, and run through all the principal streets and most crowded thoroughfares in Dublin, with the most perfect success. On one occasion it was run three times round Stephen's Green at the rate of eighteen miles an hour. Having remained eight days in Dublin, the carriage was re-shipped on board the *Shannon*, and arrived safely at its old quarters at Stratford.

As experience had proved that in some instances even the "Era's" engines were scarely powerful enough to bring the loaded carriage over new laid gravel in steep ascents, it was determined to build a larger carriage, capable of carrying twenty or more passengers, and to be propelled by engines of larger capacity. This carriage when nearly finished was, at the particular request of a party, converted into a drag, and on some of its first trials drew after it, on a level road, at the rate of ten miles an hour, three omnibuses and one stage coach, carrying on the whole fifty passengers.

On the 30th June, 1835, this drag with an omnibus in tow, took up at the House of Commons a party of gentlemen, eighteen in number, and proceeded through Whitehall, Charing Cross, Regent Street, Oxford Street, and by Shepherd's Bush to the neighbourhood of Brentford, and returned by the same route, at the rate of fourteen miles an hour, leaving the party at Charing Cross.

On another occasion, with an omnibus in tow, it took a party to Reading on the 18th of July, 1835. The distance, thirty-eight miles, was done in three hours forty minutes and twenty-five seconds—thirty-two minutes fifteen seconds of which were actual delays, leaving three hours eight minutes ten seconds of actual running, or at the rate of upwards of twelve miles an hour, a speed which might easily be maintained on good roads.

In the beginning of August, the same year, he ran the "Erin" to Marlborough and back. The carriage containing a party of gentlemen, left Stratford at half-past four in the morning: behind her was attached a small tender containing coke and water sufficient to have lasted to Reading, but the bar of wood, through which the bolts ran that fixed the tender to the carriage, gave way in Cheapside, and it was therefore left behind. The carriage left Hyde Park Corner by six o'clock, when, after stop-

ping for half-an-hour and taking up some more of their party, they proceeded on to Reading, where they arrived at eleven minutes past eleven. After remaining there about an hour and a-half the journey was resumed, and they reached Marlborough by half-past six, with no other accident than the breaking of one of the bands that drove the blower for the fire.

The total time on the road was a minute or two short of twelve hours, of which four-and-a-half were occupied in stoppages, leaving seven-and-a-half hours for travelling the seventy-five miles, being a speed of just ten miles an hour. There is no doubt that had not the tender been left behind, or had there been proper arrangements made for supplying the coke and water, the journey might have been made in six hours including stoppages; but it must be remembered that the engine was built for short trips, not a long journey, having been intended to run from the Bank to Paddington.

The return journey occupied twelve hours, the circumstances being nearly the same. The ascent of the long hill called Marlborough Hill, rising 1 in 12, and about a mile long, was accomplished in six minutes with a stoppage of four minutes. They arrived in Reading at ten o'clock; stopped one hour and a-half; ran through the town, and reached London at half-past five in the evening.

Shortly afterwards this same engine the "Erin" ran to Birmingham, at the desire of some capitalists who contemplated the formation of a company; and though built for short runs, as before mentioned it performed the distance between London and Birmingham at the rate of ten miles an hour, showing that with engines of double the power, a speed of from fourteen to fifteen miles an hour might be maintained throughout the journey.

In May, 1836, he put the whole of his carriages on the Paddington road, and ran them daily without any intermission for upwards of five months; during which time he ran about 4,200 miles, made 525 trips from the City to Islington and back; 143 to Paddington and back; and 44 to Stratford and back; and the number of times he passed through the City above 200. For five weeks he ran a carriage twice a day to the Bank. The average time of his carriages, running per day each was five hours seventeen minutes and a-half.

In July 1836, having altered the drag that went to Reading into a large carriage with accommodation for eighteen passengers, though, on several occasions he had taken thirty, he gave it the name of "Automaton," and put it on the Paddington Road.

The first time the "Automaton" was brought out upon the road, it took a party to Romford and back at the rate of from ten to twelve miles per hour,

without the least interruption in its working, and though constantly running up to the end of September, had not required any repairs.

On one occasion it performed (when put to the top of its speed and loaded with twenty full-grown persons) a mile on the Bow Road at the rate of twenty-one miles per hour!

In the month of October, the "Automaton" made several trips to Epping by way of Hackney, Clapton, Woodford, Loughton, and the old road of Staple Hill. This road was selected on account of its being, for the distance, the most hilly and uneven out of the metropolis, in order that all persons might be satisfied that, with his late improvements, the carriage would perform at least ten miles an hour; and the result proved that the power was much understated, for the average of the trips out and home was eleven and a-half miles per hour, and seven miles an hour up hill.

The following list of the steam carriages built by Mr. Hancock, in the order of their construction, and the number of persons they were respectively calculated to accommodate, exclusive of the steersman, engineer, and fireman, will not fail to be interesting:

| | | |
|---|---|---|
| Experimental carriage . . . . . | 4 | outside. |
| Infant (trunnion engines) . . . . | 10 | „ |
| Ditto (enlarged with fixed engines) | 14 | „ |

| | |
|---|---|
| Era (Greenwich) . . . . . . . . | 16 inside, 2 out. |
| Enterprise . . . . . . . . . . | 14 inside. |
| Autopsy . . . . . . . . . . . | 9 inside, 5 out. |
| Erin . . . . . . . . . . . . . | 8 „ 6 „ |
| German Drag . . . . . . . . . | 6 outside, rest in carriages drawn. |
| Automaton . . . . . . . . . . | 22 outside. |

In 1838 he constructed a steam phaeton for his private use, which had seats for three persons, besides the steerer. It ran principally in the city and upon the roads east of London. On several occasions he ran it at the west end, chiefly in Hyde Park, amongst the carriages and horses, where it created no annoyance, and attracted a great deal of attention. This carriage had been run at the rate of twenty miles an hour, but the average speed was from ten to twelve.

In September, 1833, Colonel Macerone took a trip from London to Windsor and back in his steam coach, with eleven passengers, including the fireman. The distance is 23½ miles, and the trip was made at an average speed of 12 miles an hour; and another trip in October following, to the same place and back, gave the same results.

On the 4th October, 1833, Mr. Gordon accompanied the Colonel to Edgware and back, a distance of 16½ miles, which was accomplished, exclusive of stoppages for water, in one hour six minutes and

thirty seconds—a duly performed average, throughout the distance, of 15 miles per hour.

In December, 1833, Mr. Ogle, accompanied by several gentlemen, proceeded with his steam carriage from the bazaar in Portman Street, to the residence of Mr. Rothschild, on Stamford Hill. The distance of seven miles was accomplished, notwithstanding the crowded state of the roads, in thirty-one minutes.

In the same year, Mr. Richard Roberts, the well known engineer, brought out a steam carriage of his own construction, which worked pretty well; but not succeeding to the extent he desired, he did not prosecute his undertaking any further.

On the 26th April, 1834, Mr. Gordon and Colonel Macerone travelled five miles out from the Colonel's premises, and five miles back again, at the average speed of thirteen miles an hour.

In 1833, Sir Charles Dance came to London with his steam coach, and had it repaired by Maudslays, and shortly after a patent was taken out for improvements in the boiler in their joint names.

On the 18th September, in the same year, they made some short experimental trips on measured ground, when it was found that the steam-drag and omnibus attached, had travelled steadily $2\frac{1}{10}$ miles at the rate of sixteen miles an hour. Mr. Alex. Gordon timed this experiment.

On the 20th, they left London for Brighton, with twelve gentlemen and three other persons and the omnibus in tow, and the journey was completed in six hours 22 minutes 15 seconds; and deducting one hour six minutes stoppages, in five hours 16 minutes 15 seconds actual running time. The distance from Westminster Bridge to Brighton Church being fifty-two miles.

Next day they left the Gloucester Hotel, Brighton, still having the omnibus in tow, and completed the journey from London to Brighton, and Brighton back to London, without any failure in the machinery. The total time on the return trip being five hours 55 minutes, 30 seconds; and deducting 56 minutes for stoppages, the actual running time was four hours 59 minutes 30 seconds. Mr. Alex. Gordon took notes of the time both ways.

On the 10th October, accompanied by twelve gentlemen, Sir Charles took a trip to Beulah Spa, near Norwood. The distance, seven miles, was gone in 46 minutes 30 seconds; being at the rate of nine miles an hour. The trip back was done in 36 minutes 30 seconds, being at the rate of eleven-and-half miles an hour. and this road very hilly.

On the 12th of the same month, the steam-drag and omnibus were put upon the road between Wellington Street, Waterloo Bridge, and Greenwich,

where it continued to run for a fortnight, with the view of showing the public in London, what could be done. The proprietor had no intention of making it a permanent mode of conveyance, and therefore kept the company as select as he could, by charging half-a-crown for tickets each way.

On the 1st November, 1833, the engine and omnibus were put on the mail coach line of the Holyhead road, with the view of seeing if it would perform a journey of considerable length. This engine had two cylinders seven inches in diameter, with a 16-inch stroke, and an average pressure of 100 lbs. steam was maintained in the boiler.

The weight of the engine, omnibus, coke and water, passengers and luggage, was just six tons. The weather was by no means favourable, there having been much rain in the course of the night and morning, which had made the road heavy, added to which the winter coating of materials had, in many places, been laid upon the road.

Before the carriage had proceeded six miles, one of the tubes of which the boiler was composed was found to leak so fast as to render repair absolutely necessary. It was also apparent that the size of the engine was not sufficient to carry so great a weight along a heavy road at any high velocity.

However, in spite of these obstacles, it was found,

on arriving at Stony Stratford, 52½ miles from town, that the average rate of travelling had been seven miles per hour.

In August, 1833, the Messrs. Heaton, who had patented and made a steam drag for running on the road between Worcester and Birmingham, in ascending the Lickey Hill, unfortunately broke some part of their machinery; but having had it repaired by the 28th, they again started to try the same road. Attached to the steam drag was a stage coach weighing 15 cwt., and with fifteen passengers on it, 1 ton 15 cwt. They picked up five more passengers shortly after starting, and arrived at Northfield, a distance of nearly seven miles, in fifty-six minutes.

Having taken in water, they started and proceeded to ascend the Lickey Hill, a rise of 1 in 9, and 1 in 8 in some places; many parts of the hill were very soft, but by putting both wheels in gear they ascended to the summit, 700 yards, in nine minutes, drawing the coach and passengers with them, After proceeding to Bromsgrove, the drag and carriage returned, and on descending the steepest part of the hill they proved their power by stopping suddenly. This hill is one of the worst upon any turnpike road in England. The coke consumed cost 2*s*. 6*d*. for the twenty-nine miles' run, being rather less than half a bushel per mile.

In the month of December, 1833, the following steam coaches and drags were built or building in London and its vicinity:—

| Name. | No. | Description. |
|---|---|---|
| Hancock | 1 | Infant—his own; built; experimental one. |
| " | 2 | Era—for a company; built. |
| " | 3 | Enterprise—for a company; built. |
| " | 4 | Autopsy—his own; built. |
| " | 5 | A new one—building; his own. |
| Gurney, Stone, Gibbs, and Maudslay | 1 | A drag—built and altered by the said engineers for Sir Charles Dance, Kt. |
| Ogle | 1 | A carriage—his own; built; experimental one. |
| Squire | 1 | A carriage—himself and others; experimental one. |
| Fraser | 1 | A carriage—himself and others building; experimental one. |
| Gibbs and Applegath | 1 | A drag—themselves; experimental one; built. |
| Gatfield and Bower | 1 | Ditto ditto, building. |
| Andrew Smith | 1 | A drag (for Mr. King)—experimental one; building. |
| Palmer | 1 | A drag—his own; experimental one; built. |
| Redmund | 1 | A carriage—experimental one; building. |
| Joseph Manton | 1 | A carriage—his own; experimental one; building. |
| Phillips and Co. | 1 | A carriage—their own; experimental one; building. |
| Silk | 1 | A carriage—his own; experimental one; building. |
| Smith and Co. | 1 | A carriage—for company; experimental one; building. |
| Mile End (name not known) | | A carriage—for company; experimental one; building. |

In April, 1834, Mr. Scott Russell (the designer and builder of the *Great Eastern*) established a line of steam coaches between Glasgow and Paisley, as the regular mode of conveyance. These ran for many months with the greatest regularity and success, and the trip, a distance of seven miles and a-half, was run in from forty to forty-five minutes.

An accident, caused by the breaking of a wheel, which happened to one of these carriages, being unfortunately attended with fatal results, caused the Court of Session to interdict the whole set of carriages from running—a fine specimen of Caledonian wisdom.

Many other persons tried their hand at steam carriages during the last thirty years, amongst whom may be mentioned Dr. Church, of Birmingham, Messrs. Maudslay, Fraser, &c., all with more or less success, mechanically speaking, but the shamefully oppressive tolls our enlightened Government suffered to pass, and which, by preventing their running, except at a dead loss, completely disgusted them, and they one and all took their carriages off the roads, or gave up their construction, so that all speculation in this direction, except the construction of Traction engines for foreign countries, and a few pleasure carriages for noblemen or gentlemen of fortune, has been completely in abeyance for the last twenty-five years.

# CONCENTRATED WEIGHT.

THE idea of employing steam power to drag carriages over common roads, and thus save a large outlay for horses, was suggested by various enterprising minds, but to its practical and profitable employment there have been found many great and serious objections.

In endeavouring to carry out this desirable object, very little consideration seems to have been given by the majority of those who have tried to employ steam for traction purposes to the injury to the roads and loss of power arising from the system on which nearly all of them have started, viz., that of CONCENTRATED WEIGHT.

Why most inventors should have done so is not difficult to account for, because this system, to the non-practical man, has much to recommend it, and many things in its favour. First, it *looks* better; next, it is simpler; next, under *favourable circumstances*, it can be made to work; next, it is what *all* would adopt and a[illegible] *until they found its inability*

*to carry out their intentions;* and for these, and numerous other reasons, it would at first command the preference of those, not aware of the practical difficulties and objections which prevent its regular employment, even where it could be made to work.

One of the most serious difficulties under which this system labours, when tried to be carried out for general tractive use, is the *want of adhesion* when used for *drawing loads on ordinary roads,* leaving out of the question the damage caused by the concentration of great weight on a small bearing surface.

That this is not a theoretical objection, may at once be seen on referring to the patent list, where may be found most of the various plans attempted to obtain it, and which may be summed up as follows:—wheels with SPIKES, PROJECTIONS, or RIBS *on their tires,* to give them *a firm hold on the ground.* Endless series of CLAWS or feet for *catching hold of the earth in succession, and impelling the carriage.*

Impelling LEGS or LEVERS, *which by repeated backward strokes force the carriage onward.*

Supporting legs, by which the carriage or implement is converted into a walking machine.

It has been, and is frequently alleged, that *none* of these plans "injure the roads," but how this can be reconciled with the principles of their action,

that of "catching hold of," "entering into," and "obtaining a firm hold of the ground," &c. (processes which strongly impress upon one's mind similar effects to those produced by drawing a cat by the tail across a trim flower bed), I am utterly at a loss to conceive. However, I think the errors of this plan of construction are too self-evident to need further comment here.

As far as obtaining bite or adhesion for propelling a load by such means goes, there can be no doubt of the perfect efficiency of it; in fact, *provided the ground does not give way with the strain*, it acts on the principle of the cogged wheel and rack; but of course this principle is not at all likely to damage the ground it passes over.

On all common roads, no matter how well they may be constructed, there is a certain degree of roughness, which it is impossible to remove; and this causes so great a friction, that to overcome it much of the drawing power is consumed without giving a proportionately useful effect.

Independently of the ordinary and unavoidable roughness of common roads, all highways are more or less uneven, because to construct them upon a perfect level throughout, would be attended with an expense which the traffic from no tolls could sustain.

The general unevenness of roads, therefore, causes

a great loss of drawing power; and under these circumstances, it is evident that for the avoidance of friction and economising of forces, an entirely new system to that ordinarily tried must be employed, and a full description of this new system, and its practical working, will be found further on.

In order that the disadvantages of this system, arising from its principle of action, collision with obstructions, friction, &c., when used for traction purposes, may be more easily understood and appreciated, the following diagrams are appended:—

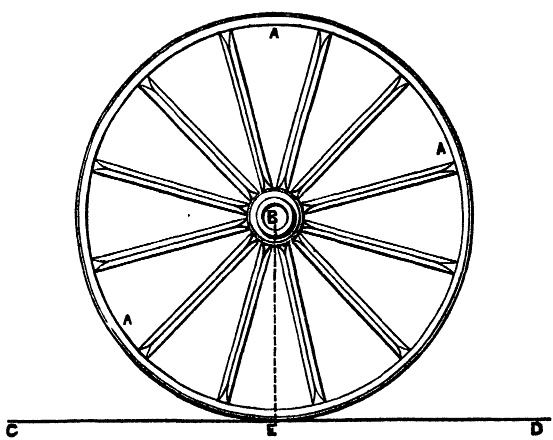



Fig. 14.

Fig. 14, represents the action of the principle of CONCENTRATED WEIGHT. Let A A A be the driving wheel, for example, of an engine, and let us suppose

the one on the further side to be exactly hidden by the one we are now looking at. Let the weight of the engine carried on the axle at B be eight tons, (which is not less than usual); now this weight is transferred in the direction of the dotted line from the point B to the ground, where the *whole weight is concentrated* in the spot E, and gives in this case a load of four tons, not including the weight of the wheel concentrated at the point E. Supposing that these wheels have tires each 12 inches wide, we have a pressure equal to nearly seven cwts. per inch breadth of wheel on the bearing surface at E.

Fig. 15, represents what is termed the resistance from collision. The resistance by collision is seldom

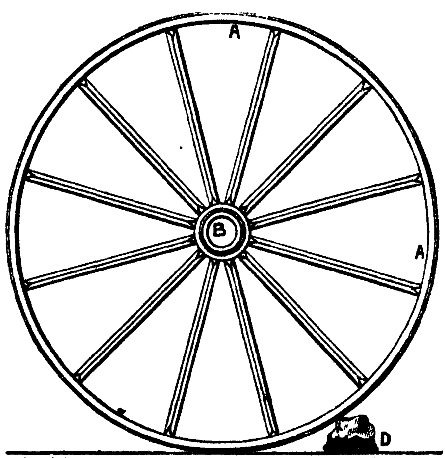



Fig. 15.

a constant retarding force; loose stones, or hard substances are sometimes met with, and will give a sudden check to the drawing power, according to the height of the obstacle, and the momentum thus destroyed is often very considerable. That this is the case the diagram Fig. 15, will clearly prove; we here see a wheel A, 52 inches in diameter, running on an axle B, 2·5 inches in diameter, the weight of the wheel A being 200 lbs., and the load on the axle at B = 300 lbs.; at D is a stone, or other obstacle, four inches in height, over which the wheel is to pass or be drawn. Now, the power necessary to pull it over is = 314.3 lbs., and the pressure at the point on the stone, where the periphery of the wheel touches it, = 591 lbs.

It is very evident in this case that one of three things must happen; either the stone must be forced into the ground; it must be crushed by the weight; or the wheel must go over it; and to illustrate it more clearly it is assumed that it goes over it.

The injury which the road sustains, by this pressure acting on a small point, and in an oblique direction is very great, especially when a heavy engine on this plan passes over it; but it is not alone in this that the road suffers; the force with which the wheel strikes the surface in its descent

from the top of the stone is considerable and would soon wear a hole in the hardest road.

By enlarging the diameter of the wheel, the power required to draw it over an obstacle will be diminished, and should the weight on the wheel remain the same, the power will *decrease* nearly as the diameter of the wheel *increases.* It has been shown that when the wheel was 52 inches in diameter, which is the general size of the front wheels of waggons, it required about 314 lbs. to pull the load over an obstacle 4 inches above the general surface. Suppose, now, that the hind wheel of the diameter of 64 inches is to be pulled over the same obstacle, the power required is found to be only 305 lbs., although 70 lbs. additional weight is obtained by enlarging the wheel.

The next resistance is friction, or that which arises from the wheels being forced over obstacles which break down under the weight, or when they are drawn through mud or other soft substances, or when the material of which the road is composed (such as gravel or small stones) is put on a soft or yielding substratum in layers so thin that the weight of the wheel can make an impression in it, and force it down so as to form a rut, and in order to render this plain let A A A Fig. 16, represent a wheel, with its

load at the point B resting on the horizontal road D, the surface of which is hard and solid, but covered with mud, sand, or gravel, to the height of the line F. If it be very soft, the wheel as it rolls along will pass through it as if it was water, and rest on the hard and firm surface D. If it be of a more tenacious nature as some clays, or composed of sand or gravel,

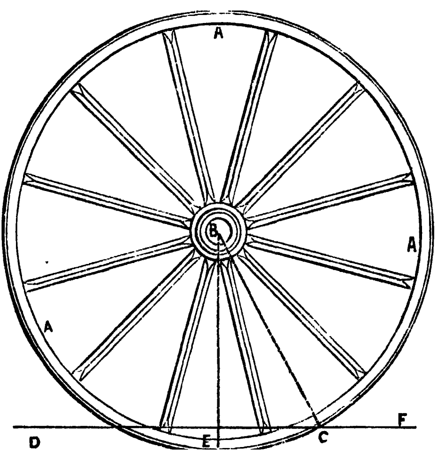



Fig. 16.

which the wheels will only compress without displacing it, the wheel will not go to the hard surface, but approach it in proportion to the weight on the axle or wheel, and the compressibility of the material over which it passes, so that it works up a perpetual incline.

A heavily loaded wheel will sink deeper than a light one, if both wheels are of the same dimensions. At the point C where there is no weight, the surface is undisturbed, and at the point E the material composing the road is compressed and sunk as much as it can be by such a weight; all the intermediate part between E and C is pressed by a less weight, decreasing from E towards C and is proportionably compressed or lowered.

The resistance which is opposed to the wheel evidently arises from its action upon that portion of the sand and mud contained between E and C, and the power necessary to overcome this, will depend upon the length of lever at which it acts, or the depth to which the wheel sinks, and the stiffness or incompressibility of the substance which covers the road. If there be no solid or hard substratum under the outer crust, there will evidently be scarcely a limit to the depth to which the wheel will sink; thus when a cart is drawn through a ploughed field, it is well known that the wheels will penetrate to a depth proportionate to the load, and the labour of drawing it will be increased accordingly. This effect is nearly the same as that which takes place when a carriage is drawn over a weak gravelly road, and is evidently more injurious to the horses drawing (where horse power is used) than when they work on a solid

firm road, although it be covered with an inch or two of mud.

We here see the disadvantages of this plan in the common working of ordinary carts and waggons, and that they become far more serious when it is applied to steam engines for drawing loads on common roads, the following remarks and account of their failures on several occasions, plainly show.

An engine of great weight, propelled by and supported on the tires of broad wheels, to be efficient, must be supported on *hard ground*, and is under these circumstances in a similar condition to a locomotive, which will move itself, and draw a load, so long as it remains upon the metals; but take it off the *hard road* or the metals, and it will hardly move itself, and will, if left alone, sink into the ground until it has obtained a sufficient amount of bearing surface to support it.

Now, to take the case of the Traction Engine, weighing ten tons, supported on a tire 12 inches wide on each of the driving wheels, this gives us a pressure, after deducting two tons as the weight on the leading wheels, of four tons for each wheel, or nearly seven cwts. per inch of breadth of wheel, pressure on the bearing surface, as shown in Fig. 14, a weight sufficient to do serious damage to any road

where the propelling power is obtained through these wheels, especially in wet weather, or on soft ground where there is a tendency to slip.

When the weight of the engine rests on four wheels and is caused to move along a rough road, greater power is expended in moving it, because of the necessity of lifting the mass over the inequalities, when they are hard enough to support the weight without being crushed; and if the inequalities are of such a nature as to be crushed down, power is lost in crushing them; if they are loose, as pebbles, they may be pushed aside, and power is therefore wasted in moving them.

It will be evident *that, as the whole weight of the load is supported on points*, the bearing surface being at a tangent to these points, they will penetrate the surface of the road more or less deeply, ruts will be formed, varying with the weight supported, and also according to the material of which the road is made, and its hard or soft state.

When the wheel rests on a soft and loose road, it sinks as far as the road material yields, or until the resistance caused by the ground against the sunken portion of the circumference of the wheel enables it to support the weight. If the wheel is moved on, it will be seen that the soil *behind the wheel* does not resume its original condition, but remains compressed,

and the wheel leaves a track, or rut. It is evident that, if the wheel be no longer supported by the hinder portion of the rut, it must be altogether supported by the anterior portion, which forms an inclination constantly before it whilst in this condition, and to mount or depress which *a great amount of power is expended,* to a certain extent uselessly, inasmuch as if by any simple means the production of this artificial and useless inclination could be prevented, all the extra power and damage would be saved.

Gurney, who was one of the first to run steam carriages on common roads, says, after using them to draw a heavy load, "my first carriage, of a given power, weighed four tons; this weight was severely felt, *in consequence of its effect on the roads.*" He states that when he had a heavy weight attached, he was "obliged to go with both wheels locked," or in gear with the driving power, when the "same weight would have been propelled by one wheel only, in very wet or dry weather." He says, "it is only in starting on a level or slight incline that this difficulty occurs, but up hill we have sometimes been obliged to attach both wheels, the bite only from the one wheel, not being sufficient to propel a load behind it."

It may be remarked that in the case of a heavy

weight concentrated on a small bearing surface, a great deal of difference exists in the wear and tear of the surface, according as the load is *drawn*, or *propelled* by the adhesion of the wheel. When the load is *drawn*, the pull of the draught being through the framing to the wheel, the tendency is for the carriage and load to move *faster* than the wheel, consequently the surface of the ground suffers only in proportion to the weight per square inch of bearing surface, and the rolling friction of the wheels.

When, however, the carriage and load are *propelled* by the adhesion of the wheel or wheels, the circumstances and effects are *very different*. In this case the motion being obtained by moving the wheel, which by the bite, adhesion, or friction on the road obtains sufficient resistance to enable it to move the load, the natural tendency of the wheel is to advance *faster* than the load, which it will inevitably do, if the adhesion be not sufficient to overcome the resistance of the weight or load, causing the effect known as slipping, by which serious damage is done to the surface on which this effect takes place.

That this is a necessary consequence of the principle is at once evident, by the various plans adopted by practical men from the commencement of road locomotion to prevent it, among which may be

enumerated the roughing of the periphery of the propelling wheels; indenting them like a cog wheel; and even that of furnishing them with teeth, claws, or spikes, which project when in use some inches from the face of the wheel, as was proposed by Trevithick, Vivian, Seaward, and others, and all of which contrivances have been resuscitated within the last few years; and must, particularly the latter, greatly tend to improve the surfaces over which they pass, especially if they do so often, and the surface be not extremely hard and in good condition.

On hard roads the traction is sensibly proportionate to the weights of the carriages, other elements being equal; and within certain limits the traction is independent of the number of wheels.

The results of numerous experiments show, that on solid roads it may be admitted as a law that the traction is inversely proportionate to the diameter of the wheels.

From experiments made upon wheels of different breadths, but having the same diameter, it has been found that on soft ground the resistance to rolling increases as the width of the felloe, and that on hard ground and roads of like firmness, the resistance is very nearly independent of the width of the felloe.

It has been found that on soft ground traction has no sensible augmentation with an increase of velocity,

but that on solid and uneven surfaced roads it increases with an increase of velocity, and in a greater degree as the surface is uneven, and the vehicle has less spring.

Some experiments made with the carriage of a siege train on a solid gravel road, and on a good sand road, gave the following deductions:—That at a walk, the traction on a good sand road is less than that on a good firm gravel road; that at high speeds the traction on a good sand road increases very rapidly with the velocity, as a vehicle without springs on a good sand road gave a traction 2·64 times greater than with a similar vehicle on the same road with springs.

In relation to the destructive effects produced by vehicles on roads, it is advantageous to employ, for all vehicles, wheels of as great a diameter as can be used, having due regard to their requirements.

The smaller the diameter of the wheels, the less the breadth of the felloes; and the higher the velocity of a vehicle, the greater the wear and tear of the roads.

Experiments made with two waggons, one being set upon springs and the other not, but alike in all other respects, shewed that the wear of the roads, and the increase of their traction after heavy weights had passed over the same track, was sensibly the

same, whether for the waggon without springs, going at the rate of 2·5 miles per hour, or for the waggon with springs, at a rate of 7·1 miles per hour.

The friction or resistance of roads has been stated by Babbage and others to be as follows:—On a well-paved road, 1-71st part of the load; on a gravelled road, 1-35th part of the load; fresh earth on ditto, 1-16th part of load. Other and later experiments shew that a waggon with its load, weighing 1000lbs., requires, in loose sand, a traction force of 250 lbs., or 1-4th; fresh earth, 140 lbs., or 1-8th; common bye-roads, 106 lbs., or 1-9th to 1-10th; hard dry meadow, 40 lbs., or 1-25th; dry high road, 25 lbs., or 1-40th; hard macadamized road, 33 lbs., or 1-33rd.

If we take stones of mean diameter from $2\frac{3}{4}$ to $3\frac{1}{4}$ in., and on a road slightly moist and soft, place them first under the fore wheels of a loaded waggon, and then under the large wheels, we shall find that in the former case the stones pushed forward by the small wheels penetrate the surface, ploughing and tearing it up; whilst in the latter, being merely pressed and borne upon by the large wheels, they undergo no displacement.

From this experiment it may be concluded that the wear and tear of the roads by the wheels of carriages is greater the smaller the diameter of the wheels. It should be remembered, however, that on

a hard dry road the effects produced by the carriage or engine wheels running into contact with loose stones, are of a very different and far more injurious character.

Now, the system of carrying the great weight of an engine on plain wheels, even with a great breadth of tire, is constantly found to fail in practice, and the blows and shocks it receives when passing over hard, rough ground, or paved roads or streets must be experienced to be understood, and of the destructive effect of this on the engine no one can have any doubt.

In order to show how completely this system fails when attempted to be brought into general use, I will instance the following condensed accounts of the failure of an attempt to work such an engine drawing a load:—

"A mining company, whose mine was situated on a heathfield, comparatively level, and broken only by gentle undulations, had a wharf within 3¼ miles of a spot whence it was proposed the engine should take its load, so that it might work regularly from it to the wharf, whence the ore, &c., would be shipped. It was considered by the company that if the engine could draw a load across the heathfield to the wharf, it would be a great advantage, and the engine was accordingly put to the test. All being ready, it left

the wharf, without any load, and accomplished the distance of 3¼ miles in exactly one hour.

"Here two trucks had been loaded, each with ten tons of iron, by the road side; when the engine attempted to move them one side of the road gave way, and the wheels of the trucks sunk into the ground nearly to the axles; after two hours delay and hard labour in getting the trucks out and putting them on the hard road, the engine was started with one truck only, it being considered, from what had been seen of its action, that it would be as much as it could manage to draw to the wharf. The three miles of road between the engine and the wharf may be divided as follows: 1st, ⅞ of a mile of parish road, very nearly level; 2nd, ⅞ of a mile of mail coach road. On this part of the road is the heaviest hill on the journey, but although a heavy hill for the heathfield, it is yet one which a good horse would trot up at full speed; 3rd, 1½ miles of road from the mail coach road to the wharf. In this part of the journey there is a moderate hill, but it is downwards to the wharf. For the first part of the journey the engine drew its load pretty well, although at the most trifling elevation it was found necessary to put on the highest power, giving rise to an immense consumption of steam. The greatest tug was to ascend the hill up which a good horse would trot, and to

accomplish this, with only ten tons, the engine was taxed to the very utmost, and only reached the top by such an expenditure of steam that the tanks were nearly exhausted. On gauging the tank it was found that there was only enough water to take the engine to the wharf, without the load; and as there was no opportunity of getting a supply of water near, the truck had to be left at the side of the road, while the engine returned to the wharf, the useful result of its day's labour being to draw ten tons 1½ mile, *a result utterly disproportionate to the means used.* The truck, which the engine only succeeded in drawing 1½ mile with great difficulty, was readily drawn along the level road by *three horses.* This engine is quite out of place where the roads are rough. To overcome the smallest irregularities an amount of power quite disproportionate is required. It was originally contemplated that the engine should go up the steep hills to the mines, but to go up these hills would be purely and simply impossible, and no man valuing his life would attempt to bring the engine down again. It was then thought that over the more moderate undulations of the heathfield it might be useful, but here it is clear that, from the roughness of the roads, *the failure is equally complete.*"

Of the truth of the above remarks, and to show its

utter unfitness for general purposes, a stronger proof could not be had than the comparison of the above performance with those of the engine constructed on the system of "distributed weight," which will be found further on.

That even on the hard roads and pavements of the metropolis this plan is found inefficient, and that, on several occasions, engines constructed on this principle have got into very serious difficulties from the giving way of the ground under them, the following accounts will show:—It appears that sometime since an engine, whose weight considerably exceeded ten tons, was "steaming along the road at a speed of about three miles an hour, when, in order to avoid some newly put-down macadamized stones, it was turned towards the kerb; but that part of the road being over some cellars, suddenly gave way, and it required the efforts of a number of labouring men, aided by powerful jacks, iron levers, and plates, with enormous steam power to extricate the engine, and raise the immense weight upon the sound earth, an operation which was accomplished without further accident, after a little over an hour's delay and consequent interruption of the roadway traffic."

On another occasion it broke through into a sewer, and also some time after into more cellars by the side of the road. A trial was once made with an

engine on this principle over a road "made up with sawdust and rubbish from carpenters' shops, the subsurface being of stiff clay. The engine struggled on about 40 or 50 yards with its load (8¼ tons), but from the great strain on the engine, and the slow progress made, it was thought advisable to discontinue the experiment."

The above are only a few instances out of several of a like nature, all of which have arisen from a similar cause, viz.: the concentrating of a great weight on a small bearing surface. It is perfectly possible to support a great weight on a small bearing surface without doing much mischief, *so long as the weight be kept in a state of quiescence*, but the moment motion and momentum come into play, when united to heavy weight, then nothing, except it be of the hardest, most solid, and durable nature, can stand before them; and the greater the weight and smaller the bearing surface, the greater becomes the mischief done.

From this it will be seen that the resistance presented by a newly macadamized road, to engines constructed on this principle, renders it necessary for them to avoid it, because it becomes a very great drawback to their progress, especially if they have a load behind, first by reducing the bite, adhesion or propelling power of the engine, from this material

acting like rollers, between the face of the wheel and the ground; and, secondly, from the wheels of the waggons or carts sinking into it, and causing an immense increase in the load to be drawn, at the same time that it reduces the drawing power of the engine, leaving out of the question the jolting and shaking it must undergo; all of which are found in practice to be extremely prejudicial to the efficient and economic working of the engine.

Mr. W. M'Adam, when examined, in 1859, before a Select Committee of the House of Commons, on the subject of locomotives on common roads, remarked as follows:—"The resistance to a wheel with a heavy weight upon it, is that alone which prevents a waggon, cart, or carriage going along a road without the application of power. The friction of the axletree, which is often talked of, is very small, and, of course, if we have an engine weighing from six to eleven tons, and if you are running it on a common wheel, although that wheel is made the driving wheel, still it is the carrying wheel as well, and the resistance of the road is exactly in the same proportion as it would be on a two-ton carriage, or on a waggon carrying six tons; that, of course, is lessened in proportion to the hardness of the road. If the road is made of limestone, and is perfectly smooth

and free from dust, the resistance will be very little more than it would be on an indifferent rail.

"If you have a bad, rough, or gravelly road, or a muddy road, or a very dusty road, I think the resistance would be augmented more than in a regular proportion. I think it would not attain a geometrical proportion; but certainly the resistance would be increased; but on a perfectly level smooth road, I think that an engine might be made with a common wheel to draw a given load, say fifteen or twenty tons, but the moment you come to an inclined plane, or to a dirty loose road, the engine, I think, would stop. *Several engines were tried some years ago near Bristol, and that was the fate of them;—a serious ascent, or a newly stoned road stopped them directly.* There was one that went from Bath to Devizes in the year 1830, that was stopped by a coating of stones.

"I do not think that any engines that work without a rail under them, or without some such contrivance, would ever run upon the common roads so as to pay; an engine that has been reported on has, I understand, some little projections, which come out to such extent only as may be required, which project very much on soft ground, and very little on hard ground. It simply gives the wheel bite, it does no other good; you have still the

original mischief, which has always extended itself to every engine of this description. You must move the weight of the engine itself along an average road, along a road in average condition, with all the resistance applying to that wheel that applies to a common waggon wheel; and I think you would rob the engine of so much power in overcoming that resistance, that you would have no balance left for mercantile purposes, and but for that, I think they would have been running on the road years ago.

Mr. W. B. Adams, in his interesting work "On English Pleasure Carriages," has the following remarks on this system, which are, as I have already shown, found to be true in practice when the attempt is made to draw a heavy load:—"Wheel carriages drawn by animal power, are moved by the *external* leverage of the animal's limbs, put in action by expansive muscular force combined with gravity. Steam carriages, on the contrary, are moved by an *internal* leverage acting on the wheels by the elastic force of steam, either by a crank on the axle as a man turns a grindstone, or by some other contrivance producing the same effect. Therefore, when the wheels turn on their axes, it is necessary that the peripheries should hold firmly to the ground, and not slide on it; or the forward movement will not be obtained, but instead of it the wheels will

grind a hole, and gradually sink down. Therefore, in order to obtain the forward motion a certain weight must be placed on the wheels to increase the friction and keep them from slipping. But this weight will be unavailing, unless the road on which the wheels rest be sufficiently hard, firm, and unyielding in all parts to prevent the wheels from sinking below its surface. If it be soft it will not afford a sufficient fulcrum for the wheels to act on."

Mr. Gurney stated in his evidence, "that when the road was in a greasy state, the wheels slipped more easily, and did not furnish so good a fulcrum for propelling."

The more surface resistance is reduced the easier will be the draught, and the less tractive power will be required. This species of resistance is avoided by using hard and durable surfaces in road making. It is obvious to every one that the draught must be greater on a soft and muddy road than it is on a smooth pavement; and upon a surface of loose sand and gravel, than on a smooth iron plane.

So great and well-known are the difficulties of this system by all practical men, when used in drawing loads, from the injury done to the roads, that Farey, the engineer, remarks:—"I am confident that carriages to be impelled by steam machinery turning the wheels, cannot be made to answer any good

purpose, either for conveyance of travellers or goods, so long as they materially injure the roads, because if the wheels slip materially on the road, they will not advance the carriage efficiently."

The remarks of Gurney, Adams, and others, and the numerous contrivances adopted in times past, and also by numerous inventors of the present day, admit and prove how this principle fails them when reduced to practice, requiring some means to prevent the damage which arises from its use, when attempted to be applied for traction purposes.

During the late trial for damages brought by one of the travelling horsemanship proprietors against the owner of an engine on this principle, it was shown that it had been found unable to do its work with a load of eleven tons; and on one occasion when it came to soft ground sunk deeply into it, in fact, up to the ash pan, a sufficient proof of the failure to be expected where this system is attempted to be employed in practice, *except under the most favourable conditions.*

The following letter, relating to this subject, from Mr. M'Adam, of Bath, appeared in the *Morning Post* of the 23d February, 1860 :—

" Road Locomotives. To the Editor of the *Morning Post :*

"SIR,—Being well aware of the amount of thought,

anxiety, and capital which is brought to bear in any mechanical invention, it was with much regret that I read in a paper of Saturday last an account of a trial in which a verdict for damages was given against a company formed for the manufacture of road locomotives. Great credit is due to inventors for the comparative state of perfection to which road locomotives have at last been brought, and I the more regret the failure in this and other instances, as it tends to discourage the public and to dishearten those who are so laudably engaged for the public good.

"I had always hoped against conviction, that a successful road locomotive would in time be constructed, but it was not till the year 1857 that I was satisfied that the great difficulty had been overcome by that beautiful adaptation of an endless railway, the clever invention of the late Mr. Boydell, which, in my humble opinion, solves the principal objections to the profitable use of locomotives on common roads.

"I was so much struck with the advantage and ingenuity of this endless railway, that for my own satisfaction I obtained permission to travel with and test the first of these engines fitted with the endless railway, which I did by accompanying that engine from Thetford to London, a distance of about eighty-

five miles, drawing five ordinary timber and other waggons, of an aggregate weight of 17 tons, at an average pace of three 4-10th miles per hour.

"The varied conditions of the roads, the steepest ascent of an ordinary public road, and occasionally very severe tests to which, with Mr. Boydell's permission, I exposed that engine, quite satisfied me that my appreciation of the endless railway was correct, and that such an engine is at all times perfectly under the control of the driver and steerer. This conviction was subsequently confirmed by experiments made in the Arsenal at Woolwich; trials by the Home and Indian Governments in drawing siege and other guns over bye-roads, and recently by its successful application to the sandy tracks of the Egyptian Deserts.

"Mr. Boydell's ingenuity having overcome the chief difficulty, I feel certain that the skill of our mechanical engineers will speedily remove all others; and with the assistance of the Legislature in the equitable adjustment of the almost prohibiting imposts which exist in some localities, I have every hope that road locomotives, and these carriages with the endless railways, will be extensively used as feeders to railways, and for the facility of the shipment of coals and minerals in every part of the kingdom, and that those who have expended such

large sums of money and so much wear of mind on this subject may be ultimately rewarded.

"The only advice I would venture to offer the public is, *not to adopt light or cheap engines.* The inequalities of the ground, and the sudden shocks and strains to which these engines are exposed, require great strength and the perfection of workmanship. Moreover, the boilers are, for the safety of the public, unavoidably costly in their construction.

"I have the honour to remain, Sir,

"Your most obedient servant,

(Signed) "W. M'Adam.

"Bath, Feb. 16."

Nothing, however, in the whole affair occurred to the prejudice of the principle of steam traction on the common roads, when carried out by properly designed and constructed engines, and steam traction on the highway is destined, there can be no doubt, to take its place among the most important improvements of modern times.

It should be remembered that actual practice on the roads, good and bad, as we find them, rough and smooth, hard and soft, hill and dale, long and deep reaches of new laid metal, is the grand test of these engines; and then, and *not till then,* the decisive

trial commences, and what the results of this trial are have been shown in the foregoing pages.

In concluding this section, I must remark that, whilst at Liverpool a few months since, I had an opportunity of examining the most complete and best designed engine on this principle I have ever seen. It was designed and made by Mr. James Taylor, of Birkenhead, and intended for use as a portable crane, or for hauling a light load on *hard ground*, or pavement, if required. It is altogether a very compact well designed piece of work, and I believe has been made the subject of an engraving in the *Artizan* during the past year.

## DISTRIBUTED WEIGHT.

In this system the weight of the engine or load, instead of being *condensed* upon a given point, is *distributed or spread over a large surface,* thus entirely doing away with the mischief caused by the system just described, and rendering the moving of heavy loads on ordinary roads or soft ground, without injury to the former, of easy attainment.

The diagram (Fig. 16) shows at once the action

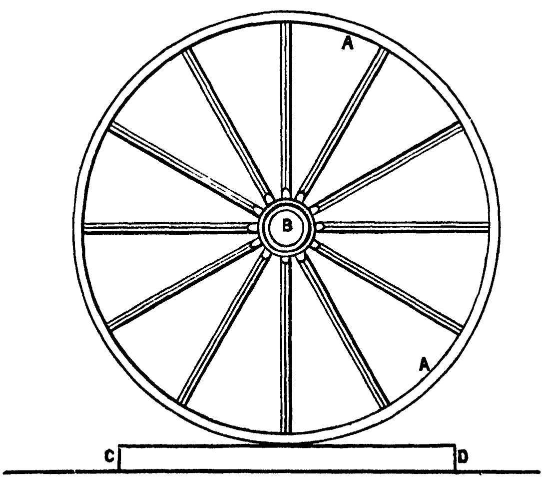



Fig. 16.

of this system. A represents the wheels of an engine or waggon, with a load at B, equal to, say, eight tons. This weight being distributed over the surface of the ground from C to D, an area of, say, 500 square inches, or 1000 square inches under the two wheels, gives a pressure of about 18 lbs. on the square inch of ground, instead of 7 cwts. or more, as would be the case with an equal weight on the other system, even with a wheel of 12 inches in width, giving a "bite" or adhesive power for propelling of 1000 square inches, instead of that which under the system of concentrated weight would vary from 12 inches upwards, according to the hardness of the bearing surface, and depth to which the wheel would sink into it.

Having given great and careful attention, for a considerable period, to the subject of maintaining a cheap, efficient, and regular system of daily traffic in drawing heavy loads, by the use of steam traction engines over common roads, or over ground opened up for that purpose, so as to avoid the effects described in the preceding chapter; and to the substitution of steam for horse power in agricultural and other operations; I am convinced that the principle of *distributing* the heavy weight of the engine, *especially when used for traction purposes, over a large surface of the ground, instead of concentrating*

*it on a small one, as is inevitably done by any system which makes the bearing surface of the ground a tangent to the circumference of the wheel, is the only one which is capable of being successfully worked in practice as a profitable investment.*

That this was felt to be the case, even in the early days of steam locomotion on common roads, may be seen from the following list of plans which were adopted to obtain it.

*Broad wheels* and *rollers.*

Fitting carriages and implements with a single *broad wheel* or *roller,* and constructing vehicles of *cylindrical forms.*

*Endless travelling railways;* comprising *endless chains of rollers;* endless chains or connected series of *short rails; series of rails* or *supporting pieces* applied separately to the wheel, but acting as a *continuous railway; circular rails.*

Wheels with elastic or flexible peripheries, whereby a *larger surface is caused to bear upon the ground* or rail, and the *bite of the wheel is increased.*

It is amusing to find how often the same plans have been revived and patented over and over again, by various persons who have given their attention to this principle; and also how little new or original has been proposed for this purpose. It would seem that the common sense precaution of

trying to find out what others had done in the way of carrying it out, had been entirely neglected.

The first person who turned his attention to this object appears to have been Mr. Richard Lovell Edgeworth, who in 1770 obtained a patent for a portable railway, or artificial road, to move along with any carriage to which it is applied. It consisted in making portable railways to wheel carriages, so that several pieces of wood are connected to the carriage, which it moves in regular succession in such manner that a sufficient length of railing is constantly at rest for the wheels to roll upon, and that when the wheels have nearly approached the extremity of this part of the railway, their motion shall lay down a fresh length of rail in front, the weight of which in its descent shall assist in raising such part of the rail as the wheels have already passed over, and thus the pieces of wood which are taken up in the rear are in succession laid in the front, so as to furnish constantly a railway for the wheels to roll on.

It appears probable, from the above description, that the pieces of wood above alluded to, were connected together in such a manner as to form an endless chain or series.

In 1801, Mr. Thomas German patented a means for facilitating the transit of carriages on common

roads by substituting endless chains, or series of rollers, for the ordinary wheels.

In 1808, Mr. John Dumbell had a patent, part of which consisted in substituting "gothic or other kind of arches, globes, semi-globes, or segments," for the ordinary wheels of carriages, in order to prevent sinking on inferior roads or bad ground.

Mr. William Palmer, in 1812, patented the use of a connected series or endless chain of rollers, as substitutes for the wheels of carriages. There were two applications of this invention—one as revolving rollers, and the other, revolving roller wheels.

Mr. David Gordon, who invented and constructed two or three road locomotives, took out a patent, in 1822, for improvements in carriages, to be drawn by elemental power. This consisted of a large rolling drum, about 9 feet in diameter and 5 feet wide from end to end, in the inside of which was an iron rack extending like two hoops at equal distances apart round the *interior* of the drum. On this rack inside the drum, a four-wheel locomotive engine on the plan invented by Trevithick, having the wheels fitted with teeth working into those of the rack was placed. By this arrangement, it will be evident that the engine, when moved forward by the steam, climbed up the interior of the drum, in a similar manner to a squirrel in its cage, and the drum would accord-

ingly move forward. The drum was steered by a carriage in front, connected by means of two side beams or frames to the engine. This system has been revised and patented with a few alterations, and in a more complicated form, quite lately, but I have not been able to find an account of its performance.

In the year 1821, a Mr. John Richard Barry, of London, patented a machine designed to enable a carriage to pass over the most rugged ground without receiving any obstruction from large stones or other abrupt impediments lying in its path.

This contrivance consisted of two endless pitched chains, stretched out by, and passing round two chain wheels, at each end of the carriage, one on each side, whose axes revolved in bearings in the side frames of the carriage which form the rails, or bearing surfaces of the carriage.

In 1825, Sir George Cayley, of Brompton, in Yorkshire, patented an apparatus on the same principle as Mr. Barry, but somewhat differently applied.

In 1827, Mr. James Neville, of Shad Thames, patented a plan of obtaining increased bearing surface or distributing the weight, which he proposed to carry out in the following manner: on the tires of the wheels were to be fastened a series of flat springing plates, each of them forming a tangent to the

circumference so that as the wheels rolled forward, each plate should be bent against the tire, and recover its tangential position as it leaves the ground in its revolution.

In 1830, an American communicated to Mr. Gillet, of Birmingham, an invention called a perpetual railway, formed by a circular rib or rail placed round the interior or felloe of a broad driving wheel, on which rail a small wheel with a grooved periphery is intended to run, and which small wheel carries the whole weight of the carriage, and by running on a smooth even surface, it was presumed it would greatly facilitate the progress of the carriage when the larger wheels were passing over uneven ground.

This invention had been patented, in 1825, by a Mr. G. Hunter, of Edinburgh, and more recently by several other persons.

In 1836, Mr. John Ashdowne obtained a patent for facilitating the draught of carts, waggons, or other carriages on turnpike or common roads, by applying an endless chain around each wheel thereof. The chain is composed of short iron bars connected together by pin joints, and is made to pass around the wheel, and over a lever guide suspended in front of the wheel.

Mr. Henry Pinkus, in 1839, in one of his patents, specified the following plan "to prevent the engine

from sinking in marshy or boggy lands, a metal rim (say 12 inches wide) may be bolted on the periphery of each wheel; and an endless apron of coarse mesh wire gauze may be stretched round the fore and hind wheels on each side of the engine; when the machine is in action the aprou will move round with the wheels, which will run upon it."

In 1840, a Mr. John Leo Nicolas specified "improvements intended to apply only in marshy and boggy situations, where wheels would sink into the soil, and could not be propelled. This improvement was a kind of moveable and portable railway, or road, which was laid down, travelled over, taken up, and carried by the machine itself.

In 1846, Mr. Edmund Leahy patented an "Adaptation of a series of short rails to the wheels of carriages, which rails were linked together in a manner somewhat resembling an endless chain; and each wheel will always bear upon at least one of the rails or links of the chain with which it is, as it were, encircled."

In 1846, Mr. James Boydell patented his "Mode of applying moveable detached parts of a railway to the wheels of carriages, whereby each part is successively placed by its wheel on the road or land over which the carriage is to pass; each piece of the railway, when down, allowing its wheel to roll over

it; and the wheel lifts the pieces of the railway successively, and holds each piece in such position as to deposit it correctly when that part of the wheel which carries a part of the railway again comes near the earth; by which means a railway will continuously be formed and broken up as the carriage is drawn along on a road or over land, by which the power required to draw a given load will be reduced."

Mr. Henry Wrigg, also, in this year patented a plan "for constructing every description of carriage, so that its weight shall always be borne by rails attached to the carriage, and resting or moving on one or more of an endless chain of friction wheels caused to revolve by the traction or propulsion of the carriage in a longitudinal direction, and this whether such carriage move on prepared or unprepared ground, and whether it is propelled by animal, steam, or any other power."

Mr. William Pidding, also, at the end of this year, patented means of "applying a portable railway" to common road carriages, consisting of a series of rollers, their axes being connected by links, so as to form an endless chain which encircles the frame. Each link carries a small wheel, which stands at right angles thereto. The wheels keep the rollers at some distance from the ground, and the rollers serve to support the carriage.

Another modification consists in the employment of endless bands of plates, passing under the wheels of carriages to serve as a roadway, and kept in motion by the rotation of drums or rollers driven by the wheels of the carriage.

In 1847 Mr. James Morrison patented a carriage wheel of peculiar construction, carrying a series of rails on which it travels.

Towards the end of this year, Sir John Scott Lillie, in his patent then obtained, described "an endless railway formed of wooden planks, or wrought iron plates hinged together, so as to turn freely over the drums, and circulate around the bearing wheels of the carriage which travel thereon."

In 1852 Mr. William Pidding patented improvements upon his patent of 1846.

Mr. James Nichols Marshall patented, in 1852, "an improved wheel for carriages and other vehicles," which he thus describes: "Two cog wheels made fast, one on each side of the tire of a wheel; fourteen revolving cog rails; fourteen revolvers for the cog rails to work and turn on a pivot that runs through the revolver, and through the rails, and made fast to the tire of the wheel with a joint that will allow the revolver and the rails to lay flat on the ground while the cog wheel passes over it."

In 1854, the late Mr. James Boydell patented his

improvements on his endless railway, for which he obtained a patent in 1846, "in which the parts of the rails on which the wheels of a carriage run are each fixed to a plate, by preference of wood strengthened with iron, so that the surface bearing of the plate is considerable as compared with the width of the tyre of the wheel, the plate extending considerably on either side of the rail on which the wheels run. The ends of the bearing plates are formed so as to match into each other, and in each case to extend beyond the end of the portion of rail which a bearing plate carries, so that when a carriage wheel comes to the end of one portion of rail, it does not come to the end of the bearing plate on which that part of the rail is fixed, but is received on to, and supported by the next portion of rail before the wheel has passed beyond the end of the previous bearing plate."

In 1856 Mr. William C. Cambridge patented an endless railway for facilitating the movement of engines, carriages, &c., over loose ground and irregular surfaces. To each wheel is adapted "a set of plates or sustaining pieces, made flat on their under face, which severally receive in turn the pressure of the wheel as it revolves." The railway is not fastened to the wheel, but merely forms a kind of endless chain around the periphery, from

which it may be removed by simply withdrawing the junction pin or bolt from one of the pairs of levers or links so as to break the continuity of the endless chain.

On the 12th of February, 1857, Messrs. Isaac and Robert Blackburn, of Islington and Edinburgh, obtained a patent for "Improvements in engines or implements to be employed in agriculture; applicable also to the transporting of heavy bodies, to the traction of carriages, and to the conveyance of passengers."

This is simply a revival of Mr. David Gordon's arrangement patented by him in 1822, with the exception that the boiler, &c., are hung up to, instead of supported on, the drum.

On the 18th March, 1857, Sir James Caleb Anderson, of Fermoy, County Cork, provisionally specified "Improvements in locomotive and other carriages," part of which he termed a "universal railroad," which is just that proposed to Gillet in 1830.

On the 25th May, 1857, Mr. Henry William Ford, of Gloucester, provisionally specified "Improvements in apparatus for facilitating the draft and locomotion of carriages," which was identical with the above.

On the 16th of June, 1857, Messrs. John Fowler, jun., Robert Burton, and Thomas Clarke, all of

London, obtained letters patent for "Improvements in a method of causing the wheels of carriages to lay for themselves rails on which to run."

On the 24th June, 1857, Messrs. Hamilton Henry Fulton and Thomas B. Etty, of Westminster, provisionally specified a "means for increasing the traction and bearing surface of carriage wheels," consisting of an endless chain or band of any flexible material, nearly as proposed by Pinkus.

On the 3rd July, 1857, Messrs. Dumarchey, Levy, and Mayer obtained letters patent for improvements in wheels for common road carriages, which consisted in fastening a broad hoop or tyre of sufficient width to extend over the tyre of the wheel of the carriage.

On the 31st August, 1857, Mr. William Clark of London, patented "Improvements in the application of portable rails or ways to vehicles," consisting of applications of an endless chain of six, eight, or other number of bars or rails jointed together surrounding each wheel of the vehicle.

On the 29th September, 1857, Mr. James Welsh, of Southall, Middlesex, provisionally specified "Improvements in carriages and portable railways."

On the 6th March, 1858, Mr. Andrew Whytock, of London, provisionally specified "Improvements in apparatus to be applied to wheels to facilitate

them in travelling on common roads and other surfaces."

On the 7th June, 1858, Messrs. Edmund Scotson and Henry Charnley, of Preston, obtained a patent for "Improvements in traction engines, and in endless railways, consisting of a chain provided with as many studs and lozenge-shaped pieces as will reach entirely round the wheel, and these sections are so arranged that as the revolution of the wheel carries them round, they are successively laid down in front of the wheel."

On the 13th August, 1858, Mr. Thomas Rickett, of Buckingham, obtained a patent for the invention of "Improvements in locomotive engines and other carriages," nearly similar to the endless band or web proposed by Pinkus in 1830.

On the 27th August, 1858, Messrs. John Fowler, jun., and Robert Burton, of London, obtained letters patent for "Improvements in the construction and arrangement of locomotive and other carriages to facilitate their movements on common roads and other surfaces." For this purpose the axle (or it may be axles) of the carriage is supported at its ends by frames, and these are supported on wheels which run upon rails laid by the carriage in its progress. The wheels have flanges on both sides of the tire, and an endless chain of short sleepers or bearers, each having

a length of rail bolted longitudinally to it, passes round each pair of wheels.

On the 7th October, 1858, Mr. Charles Henry Thurnham, of Dalston, provisionally specified "Improvements in the construction and application of certain mechanical arrangements, to be adapted to the wheels of locomotives, carriages, and other vehicles, for facilitating their traction or draught." These consisted of a peculiarly constructed ring, which can be slipped over the tire of the ordinary wheels of vehicles of every description, so that the carriage wheel can work therein, and while itself rotating, will rotate the external ring, which thus becomes a kind of annular railway or tramway, for the several wheels of vehicles thus provided to, travel upon.

On the 13th October, 1858, Messrs. James Braby and James Braby, jun., obtained letters patent for "Improvements in wheels and wheeled carriages to be propelled by steam, horse, or other power," which is very similar to Gillet's, before mentioned.

On the 27th November, 1858, Mr. Charles Burrell, of Thetford, obtained a patent for improvements in traction engines and carriages, which consisted in a modification of the means used for attaching the shoes of Boydell's endless railway to the wheels of engines and carriages.

# BOYDELL'S TRACTION ENGINE AND ENDLESS RAILWAY.

HAVING thus described the principle of distributed weight, there can be no doubt that Boydell's patented arrangement for carrying out this principle is, up to the present time, the only one which can be regularly and profitably worked over the same ground without injuring it, and as it is the only engine on this principle which has ever been regularly worked, a short description of its capabilities and power, gathered from the results of actual working in different parts of the kingdom, often under my own observation, and not from a few isolated experiments, will be found in the following pages.

The peculiarities of this engine consist—First, in the shoes forming the endless railway, attached to the driving wheels, and revolving with them, and also attached to the steering wheels, if needed, by means of which it is enabled to pass over any ground, and to draw heavy loads on common roads without injuring them.

Secondly, in being fitted with means for adjusting and maintaining the water in the boiler at a level, or nearly so, under all circumstances, whether ascending or descending hills, it being only needful to know beforehand the greatest inclination to be worked, in order to accomplish it, an advantage no other engine possesses; it is also under the most perfect control, and is most easily managed.

Next, it can be so fitted as to be used as a stationary engine, when required, for working saw mills, thrashing machines, &c. Next, it is supplied with a train of waggons when used for drawing loads, so arranged that each waggon will follow exactly in the track of the engine wherever it goes, turning corners at right angles, and capable of being manœuvred in any direction, with the greatest ease and precision, only requiring the attention of one man to the waggons, whether there are five or fifty, and an engine and train of five waggons and two carts, a length of more than 130 feet, have been turned round in a space not exceeding 35 feet wide.

The accuracy with which these trucks follow in each other's tracks is surprising, not only when going straight forward, but even in taking a sharp turn; in the latter case I noticed the impression left on the ground by the ten wheels following one

another to be only twelve or thirteen inches, while the width of the wheels was nine inches, leaving but three or four inches for deviation of course; and that when different parts of the train were at one time moving in three different directions. The wheels of the trucks can be so made as to have shoes or the endless way fitted to them.

The engine consists of an ordinary locomotive tubular boiler, has two horizontal cylinders, mounted on a framing and supported by a pair of iron driving wheels of seven feet in diameter, to which the endless railway is attached, as shewn in the Frontispiece.

"The Endless Railway" attached to Locomotives is the *only means hitherto invented* by which steam can be used advantageously on ordinary roads under all circumstances, by removing all direct friction of the wheels on the surface over which they pass.

In the centre of the shoe, either through the centre of the rail, and tire and rim of the wheel, on one side of the rim, or both sides, rises a cycloidal arch of iron, called the A, answering to the ancle, and by which, through the agency of a stud projecting at right angles from the top, and an inch or so in length, or by another arrangement if the A's or cycloids are double, the shoes are attached to the wheel so as to be taken up, and put down by the wheel, and yet allow it to run upon the steel rail;

the shoes revolve with the wheel, and the wheels revolve upon the shoe, each being taken up by the wheel as soon as it has passed over it, and another being put on the ground in its place—this action will be easily understood on referring to Fig. 18.

These shoes act entirely independent of each other, and change their position at the top and bottom of the wheel, as just explained, the heel falling over by gravity, soon after passing the top of the wheel; thus, as each shoe comes to the bottom of the wheel, the heel is ready to receive it, just as it has passed over the preceding shoe; the shoe being quite stationary whilst the wheel passes over it, and forms a complete and continuous endless railway. It will be seen that the shoe cannot be lifted until the engine has left it, and the engine does not pass on to the shoe in front until it is perfectly flat on the ground, so that the pins at the top of the cycloid have only to lift up and hold the shoe during its revolution with the wheel. As the friction depends only on the weight of the engine, and not on that of the load, a heavy load can be drawn at a greater proportionate advantage that a light one; the draught of loaded carts on common wheels over soft ground, increases in a compound ratio in proportion to the weight of the load carried, but it is not so in the endless railway.

F. C. Danvers, Esq., C.E., the Engineer from the East India House, in reporting on one of these engines to the Government, says in his report:—"It is a pretty sight to watch the action of these shoes, the way in which the wheel deposits them on the ground and again lifts them up, after having passed over, not being a heel-and-toe action, but sudden and flat, the whole surface of the shoe reaching the ground, and again leaving it simultaneously; they run entirely free and independent of each other, and no obstacle on the road could seriously interfere with their working."

The engine is steered by a vertical or horizontal wheel at the forward end, working the fore pair of wheels, which can easily be brought to any angle, so that the engine is thus readily and quickly guided. The boiler can be elevated or depressed, in going down or up hill, in order to prevent the tubes or fire box from becoming uncovered by the water, an occurrence fraught with the greatest danger to the safety of the boiler. This power of adjustment is a very great feature in the safety of working this engine, and where a particularly steep class of gradients have to be worked, the engine can be easily constructed to suit them. One has lately been made, in which the water can be maintained *at a level* when working on an incline of 1 *foot in* 7.

It has been admitted by the owners of an engine unprovided with this arrangement, and constructed on the principle of concentrated weight, which had been scrambling about the country in all directions, that the lead plug inserted in the roof of the fire box to prevent the damage caused by overheating the plates when its top became uncovered by water, had melted out on several occasions, evidently caused by the want of some arrangement for keeping it covered by the water when the engine was descending a hill.

I have repeatedly seen the engine and train of five waggons taken with the greatest ease and without stopping, through gateways where there has not been a greater amount of space to spare than 3 *inches* on each side of the engine, and that by a steersman who had not steered the engine until a week before. The engine and train can be moved *one inch* at a time, ahead or astern, and stopped dead by shutting off the steam, there not being, as is too generally imagined, a great amount of momentum to be destroyed. I saw the engine and seven carts and waggons, weighing, without the engine, 19 tons, 15 cwts., or, with the engine, a little over 31 tons, stopped dead when going down the steep incline through the town of Prescot, an incline similar to that of Holborn Hill, where it stood for nearly five minutes, and started off again as gently as possible.

In drawing heavy loads on common roads by Traction Engines on this principle, a great advantage is gained and much damage to the roads avoided, by the weight of the engine causing the shoe, which is lifted up and put down by a perpendicular motion, to form a broad, even, moderately consolidated surface, 16 inches in width, over the central line of which the wheels of the waggons and carts pass, so that the damage and loss of power caused by their passing over loose stones, and striking against other obstructions is avoided, and the engine can thus draw a heavier load in proportion, with the minimum amount of damage to the road, which no other plan would enable it to do; and another very important feature of it is, that the engine passing so smoothly over the endless railway, the machinery is liable to far less injury and wear and tear, than an engine or any other principle.

To show the advantage of the shoe in passing over rough ground, it may be observed that there is nothing but an incline of varying height, according to the height from the ground and position under the shoe of the substance on which the shoe rests, for the engine to surmount. I have seen a block of stone of more than 9 inches cube, placed on the ground (a hard pavement), under various parts of the shoes, first on one side and then on the other, and the

engine pass over it with the greatest ease, also over blocks of wood of various sizes, and other lumps of hard material, to the no small astonishment of those who wished to see its effect.

Mr. F. C. Danvers, C.E., in his report, thus remarks on its powers in this respect:—"In trying the working of the engine and train with a pressure of 70 lbs. steam in the boiler, I several times had it taken over a mound of straw or rubbish lying in the yard, of about three feet in height, and six feet wide; this was easily passed over sometimes by both wheels and then only by one." The engine had five waggons with spare gear, &c., behind it, a gross load of 15 tons.

In the following pages it is purposed to prove from practical working, in the presence of those capable of judging, its perfect adaptability and advantage for general haulage purposes.

*First,*—of its great utility to railways for branch traffic in a thinly peopled district, or where it would not pay to construct a branch line.

As a feeder to the goods traffic of railways by superseding the necessity of short and expensive branch lines, its advantages can scarcely be overrated, and its power of working on common roads *without injury to the roads,* has been fully and satisfactorily tested and proved at Woolwich, before a

committee appointed by the Government, at various other places, and also by different road surveyors, who have all admitted *after having seen it at work* that its tendency is *to improve the roads rather than damage them;* and the following important results have also been obtained; viz:—that on the best ordinary roads, the heaviest loads can be drawn with greater economy than by horse-power, and that in ascending or descending the steepest hills, or in passing over soft and marshy ground *where no roads exist,* this engine and railway have been found to overcome difficulties, which no available amount of horse power could possibly accomplish.

From what I have seen during the time my attention has been turned to the use of steam for hauling heavy loads, its cheapness, the ease and facility with which it can be managed, its safety and economy when compared with horse or animal power, as well as from the practical experience of Gordon, Gurney, Hancock, and others, it seems that in certain positions and under certain circumstances the use of steam passenger coaches, or trains, on the common roads, at from twelve to fourteen miles per hour, deserves more attention and consideration than have been bestowed on it of late years.

*Second,*—for agricultural operations the experiments have proved, if possible, more satisfactory, inas-

much as the land ploughed at different places, in the presence of a very large number of practical agriculturists, landowners, and engineers, has been pronounced by them to have been better done than by horses, while the saving of cost has been variously estimated at from 40 to 70 per cent., according to the description of the work done; and possessing this great advantage, that in ploughing on soft or wet ground, the *endless railway and engine do infinitely less harm to the land, than the horses' feet in drawing the ploughs,* and the land has been ploughed to a depth *almost impossible to accomplish by horses, in a most economical and efficient manner.*

The endless railway, when fitted to carts or waggons drawn by horses, is scarcely of less importance; by applying it to ordinary carts or waggons for use by horses, where steam power is not employed, the agriculturist would be able to cart over the soft land at all seasons without doing any injury to it.

This was fully tested in the Crimea, with the heavy guns, during the late war, and its advantages and utility were satisfactorily proved.

The great advantage of the "endless railway" was recently tested on a farm of Mr. Wood's, at Hanger Hill, Acton, after very heavy rains, in carting home a large quantity of mangold wurzel from

a field of a deep clay soil, "the result as to draft being that two horses drew with ease 35 cwt. in a cart with the "endless railway," attached to the wheels of 4 feet 6 inches diameter, while the same horses with considerable difficulty could only draw 15 cwt. in a cart with common wheels of 5 feet diameter and 6 inches wide, and the result on the land being that the common wheels with the lighter

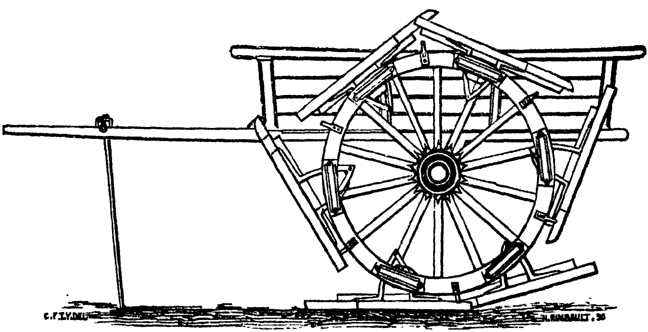


Fig. 18.

load made very deep ruts, while the track of the heavier load on the "endless railway" was scarcely even perceptible. (See Fig. 18.)

At the twentieth annual meeting of the Yorkshire Agricultural Society, held at York in August, 1857, a prize of £30 was awarded to the "traction engine and endless railway."

At Louth, in Lincolnshire, in July of the same year, the Louth Agricultural Association desired that

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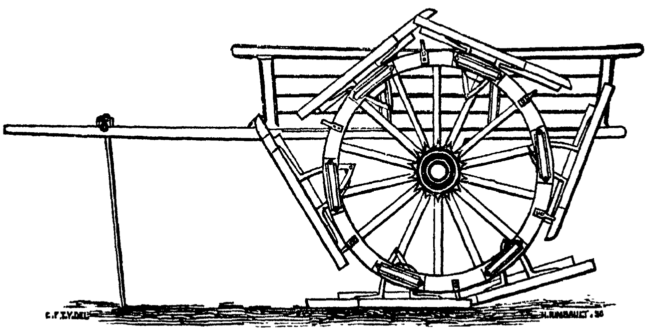

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the engine might be sent to their Annual Meeting for them to examine and report on its capabilities, and utility to agriculturists. The engine was sent down, and after having for some time been at work drawing a train of common waggons, bearing loads amounting to between 17 and 18 tons, up and down an irregular piece of hill and dale, which it did with the utmost facility, it was taken on to a field, and about half an acre of land, a dry soil, was ploughed up in "first prize" Alford style. Two subsoil ploughs were next attached, and the land was broken up to the depth of 12 inches; and finally, Coleman's cultivator was set to work, and the soil operated upon in a manner which, in the opinion of the agriculturists present, could not have been accomplished on such ground, and at that season, by any number of horses. The work of the engine was eminently successful.

A committee of the Association, at the end of a very favourable report, remarked as follows:—"From the experiments made above, your committee are led to the conclusion that the great features in the character and construction of Boydell's engine, are its capability of laying down its own railway in endless succession, of travelling upon it in any direction, under the complete control of its driver, and its immense power of traction. They see

no reason why the cost of working it should much exceed the cost of working any other ten horse power engine. In short, they recognise in this invention a great motive power at a comparatively small working cost, requiring what alone experience can give, a better knowledge of the proper mode of attaching and managing the implements to make it available for the farmer's purposes."

These experiments were tried on the land of Mr. J. Robson, of Brackenborough, two and a-half miles from Louth.

Now, a traction engine that will draw five or six ploughs at a time, and cultivate ten or fifteen acres of land a day, according to the nature and quality of the soil, that will draw on ordinary roads from 20 to 30 tons of produce to market, at the rate of three miles an hour for any distance, and bring back an equal weight of manure, lime, coals, gravel or merchandise; and when the farmer himself does not use it, may be hired out to his neighbours with advantage, cannot fail to prove a most valuable and profitable machine.

The following remarks on these engines at the Salisbury Meeting of the Royal Agricultural Society, on the 20th July, 1857, and following days, are taken from the *Times* of July 23d:—

"On Monday the steam ploughs were ordered up

to the large field purposely provided at Bishop's Down, on the crown of a hill, not far from the show yard. Boydell's Traction Engine, fitted with the endless railway, climbed the ascent steadily, and with great power, dragging after it a tender holding 1000 gallons of water, and carrying all the ploughs and tackle required. The boiler is an ordinary eight-horse power, with double cylinder engines, reversing motion, reducing gear work, water tank, ship steerage, &c., as last year, and weighs, when fully charged with water, ten tons. Yet this enormous weight, with seven tons of load behind it, proceeded up a declivity of 1 in 10 or 12, the inclination in one place being no less than 1 in 7. Mr. Fowler's ten-horse engine, weighing, we suppose, about eight tons, and made to travel upon wheels with broad peripheries, instead of being fitted with the endless rails, was only able to ascend the hill by anchoring a rope a-head and hauling up to the anchor, 'veering,' as it were, and with a slow and laborious progress. It appears to us hardly fair to subject these engines, at their first public essay, to such severe tests as directing them up all sorts of awkward roads; but the trials have fully demonstrated the great assistance which the "endless rails" are to a locomotive for farm roads and arable fields. The self propulsion of Mr. Fowler's engines along the headlands is very

simply and easily accomplished, though it is to be wished that Mr. Fowler had adopted Mr. Boydell's rails, particularly in a steep and difficult travelling country as that around Salisbury. Another feature is the application of Mr. Boydell's endless railway to ordinary portable engines, so as to render them locomotive, by very simple and inexpensive mechanism. Great value will be found in this arrangement, by which the farmer's engine can travel with its thrashing machine from one homestead, or estate, to another without the assistance of horses."

*Third.*—Of its value for the general purposes of transport, there has long since ceased to be any doubt, and if we consider the conditions a traction engine must fulfil, in order to enable it to be profitably worked, it will be seen that this engine meets them *all* in the most eminently satisfactory manner. These requirements are as follows :—

1. That it shall *do no injury to the roads.*

2. That it shall not be a nuisance to the public, by smoke, or the noise from the exhaust steam.

3. That it shall be easily managed.

4. That it shall have sufficient power to render it economical by drawing a heavy load at a light cost.

5. That it shall be free from expensive repairs.

6. That it shall be capable of being used as a stationary engine.

7. That it shall be able to take heavy loads up hills and over soft and uneven ground.

It is proposed to prove each of these conditions separately, beginning with No. 1. From the principle of the "endless railway," as applied to these "traction engines," it has been constantly proved, and is universally admitted, that the heaviest engine does not cause the slightest injury to the best of roads, while it greatly improves those that are rough, and have deep ruts, or are newly macadamized; and it is very satisfactory to the principle to be able to state, that though it has been carefully watched on numerous occasions by various road surveyors, evidently with a strong desire to find some cause of complaint, they have universally admitted that it in no way injures the roads, but rather *improves* them. That it should do so, has been satisfactorily shown and explained under the section on "Distributed Weight."

Mr. W. M'Adam, in his evidence before the select committee of the House of Commons in 1859, says: "I do not think, if you were to travel with one of these engines over one hundred miles, you could say, *speaking mathematically*, that these shoes had not worn the road. The thing that struck me as being so excellent in Mr. Boydell's contrivance was, that the resistance to the forward motion of the engine

was entirely destroyed by making the engine travel on an iron rail for nearly a yard and when the wheel arrived at the point of that rail it, in a most ingenious manner, lifted the rail it run over and laid down another for for itself to run over. The bite which the engine had upon that iron rail was sufficient in most cases to propel the load which the engine had behind it, but where the wheel had a tendency to slip, the attachment of the wheel to the shoe was such that it could not slip any more, and the consequence was that the engine had the whole hold of the shoe upon the ground, and that shoe occupied an area of something like a thousand inches, so that the bite of the engine upon the ground was equal to the area of the shoe, and the wheel could not slide because the attachment prevented it, and in a most ingenious manner the engine continued to lay down one shoe after another as it wanted them."

Now Mr. W. M'Adam is General Surveyor of Turnpike Roads, superintending several trusts in the West of England, chiefly in Somersetshire; therefore, his evidence becomes of great value in proving the efficiency of this principle, and its freedom from injury to the roads, when it is seen, that *practically* none is done, but *mathematically*, there *may* be. This gentleman, as will be seen further on, made a journey from Thetford to London on the turnpike

road with one of these engines and a train of waggons, and was therefore well able to give an opinion on the subject.

Mr. H. Browse, General Surveyor of the Metropolis and other Turnpike Roads, in his evidence before the same Committee, says—"I am prepared to say that Boydell's engine would do *very little injury* to the roads, by travelling upon them with the shoe." Here are seen two well-known gentlemen, of great practical knowledge in road matters, voluntarily coming forward before a Committee of the House, and, *having seen the engine at work*, passing a most favourable opinion on it, and declaring its freedom from injuring the roads; and in this opinion *every* one who has seen it at work, heartily concurs; in fact, it is so self-evident, and universally admitted, that no more need be said on that head; and I will therefore proceed to requirement No. 2.

Mr. J. Gibson of Manchester, a very extensive coal proprietor, and who, from having seen the working of the engine and train, was exceedingly struck with its advantages, came up to London to give his evidence regarding the engine, and on this point he states as follows:—"It has been through the principal streets of Manchester, and I believe that if I had asked every member of the corporation to sign this note, which I have read from the Mayor,

they would have been perfectly willing to sign it. (One asking if it was found a nuisance.) I asked the chairman of the nuisance committee if he had heard of any complaints, and he said *"none at all."* When the engine went from Manchester to Liverpool I followed it; I drove my mare behind it, and passed it, and put her up in a stable to let the engine go past, and she actually turned round and winnied to it to come up."

Mr. M'Adam, who had made a long journey with an engine and train, when examined on this subject before the committee, says, "We had met several cart horses; they had noticed it a little, but not enough to require us to stop. Once or twice, near London, I went forward for the purpose of holding some carriage horses, but the coachman told me not to do so, as he would be able to manage them; the horses just stared at us and then went on. Generally speaking, when we came to the towns we were inconvenienced by the number of people who were riding round us; we had forty or fifty people riding round us in one of the towns. Some of the horses made a great objection at first, but the gentlemen coaxed their horses up to the engine, and the thing ended in every one of them following us. We never had anything to do but stop the engine, and then if the horse was frightened, his rider would get down

and coax him. The frightening of a horse is not, I think, a matter of so much consequence as should prohibit the use of these engines. I think the use of them will obtain some day or other, and I think, some day or other, horses will become accustomed to them. We found that at first railways were a great nuisance to horses, so much so, that in the General Railway Act, power was given to the Board of Trade to order screens to be put up for the protection of public roads. During the early stage of railways I was excessively particular about that, and insisted on screens being erected; some of those screens have since worn out; other railways have been made since, and I have endeavoured to get screens put to them, but the very gentlemen who had been in the habit of using the road have said, *that they did not want them;* and I think myself, and I know from experience, that horses have become accustomed to railways; and I think that they would become accustomed to these engines in the same way. Now horses that use turnpike roads now-a-days, are wonderfully constant to particular pieces of road; we find on passing through gates, that we have the same horses week by week and day by day. Our through traffic is entirely absorbed by railways; if a horse saw an engine to-day he would see it again to-morrow, and would soon get reconciled to it."

From my own experience of the working of these engines through towns, along the streets, and on turnpike roads, I can safely say that not one horse in a hundred notices the engine to be alarmed at it; and I have particularly observed, that whatever horse was alarmed, has invariably owed it to the conduct of the driver, who *is always more frightened than the horse*, and who, by tugging and jerking at the reins, steering first to one side, then to the other, now stopping, now going on, easily succeeds in producing the very effect he should carefully avoid, and ends in becoming a greater nuisance than the engine and train would ever be, even if it were tried to make it so.

I was at all the trips to the colliery, and trials in Manchester, and went with the engine to Warrington and thence to Liverpool, where we met hundreds of persons who came out to meet us, and had not to stop even once for horses, although the driver was particularly ordered to stop the instant he saw any horse appear to have a dislike to pass it. In fact, the great difficulty, both in Manchester and elsewhere, was to get the people in their gigs and carriages to keep off from crowding round the engine. One carriage in Manchester, drawn by a pair of spirited horses, was several times driven right against the side of the engine, from the desire of the

occupant to get a close look, but beyond damaging his varnish I saw no effects from his proximity, and the horses did not even notice it.

We went through Liverpool at five o'clock in the afternoon, when the whole of the traffic was at its height; we met omnibuses, carts, gentlemen's carriages, and thousands of people coming to meet the engine, but there was not a moment's obstruction of any sort. We went through the streets of the City of Manchester also, in the most crowded part of the day, and met with no objection of any sort from any body.

From the application and use of the cheap, ingenious, simple, and efficient plan invented by Mr. D. K. Clark, C. E. (the talented and well-known author of "Railway Machinery"), and which is easily applied to these engines, they can be made to burn coal without producing the least smoke, a desideratum which, even on railroads, is not yet accomplished, except where this plan is used (although it is *forbidden to produce smoke* by Act of Parliament), and the cheaper fuel, coal, is thus enabled to be used with a greater economy than the more expensive one, coke, with a great saving to the employer of steam power, and the same efficiency as the present expensive coke.

It is very interesting to see how instantly the

smoke is destroyed by the simple turning of a small cock, which lets a minute jet of steam rush with great rapidity through the hollow tube stáy into the fire box above the burning fuel, drawing in and mixing the air forcibly amongst and with the unconsumed gases, converting the red lurid blaze into a short intensely white flame, totally destroying every vestige of smoke; and it works just as efficiently when the engine is standing as when running. In fact, if an engine thus fitted is seen to smoke, it is evident that the engineman has not availed himself of the means provided to prevent this occurrence, and he should be punished accordingly. I make this statement after having given great attention for some years to the various systems adopted for this purpose, both by running with them and seeing them at work; and I have remarked that, although some of them are tolerably successful in preventing, or, it should rather be said, diminishing the smoke when running, none of them are able to control it when standing, or when the steam is shut off, except by the use of a very powerful blower, or steam jet, in the chimney.

I do not like this powerful jet, as it causes the steam to rise very rapidly, as may be easily seen on any engine where it is used, if there be a Bourdon's gauge, and it will be found that the pressure rapidly

rises to many pounds on the inch above that to which the valves are loaded, even whilst they are blowing off freely, making it a rather dangerous instrument unless carefully used, especially in the case of old engines.

In the *Artizan* for July it will be seen that the London and North Western Railway Company have been fined £5 and costs for permitting "dense volumes" of black smoke to issue from one of their engines at Edgehill station. It is generally understood that the engines in use on this road are constructed so as to prevent smoke being evolved when using coal, but it seems "smoke burning" is yet in its infancy, or is not considered a desirable object by the Company.

The noise of the exhaust steam, so great an annoyance to some people, can, and is, by a very simple arrangement, so entirely obviated as not to be perceptible, and thus what has by some persons been considered an insuperable objection to the use of steam in the streets and on the roads is entirely removed and done away with. In fact, these two requirements are so completely satisfied, that it is needless to remark further on them; I will therefore turn to No. 3.

A great deal has been said about the "*probable*" difficulty of managing one of these engines and

trains; I must observe that I have *never seen any*. Of course, if a man looks one way and steers another, he will not see where he is going, and possibly mischief may arise; but with a moderate amount of attention and practice, any one may acquire the necessary knowledge for steering, in most cases, in less than a week.

The engine can be so instantaneously stopped, or moved, and so slightly, that the late Mr. Boydell, when driving a heavy train, showed some gentlemen that he could actually crack a nut without crushing it, and that he could catch the point of a walking stick between the wheel and the rail so as not to crush it, and then back the engine again, so as to relieve the stick entirely.

I have seen the engine backed up to the train to be coupled on to the waggons, and moved *half-an-inch at a time*, in order to allow the coupling pin to be dropped through the eyes of the shackle, with the greatest ease and accuracy, to the no small surprise of some of the railway men, who on several occasions have come to see the engine and train.

In fact, in the hands of *proper* persons, not the "intelligent (untaught) agricultural labourer," *so highly recommended by some people as fit for the charge of machinery*, there need be no more trouble than with an ordinary wheelbarrow, as the engine and train may go wherever wheels can be employed.

The waggons which form the train drawn by this engine are on an entirely new principle, by which one man can manage, with the greatest ease, an entire train of any length, each waggon following in the exact track of the engine, and turning round the corners at right angles, and even at reverse angles, at the same time, if the length of the train admits of it.

Of its manageability Mr. M'Adam remarked to the committee before mentioned, that "these engines are much more easily managed than horses, for the engine has no will of its own, and the horses have. An engine *properly constructed* may be quite as commandable as any four horses that were ever driven;" and in continuation it may be remarked that these engines are much more so, as daily practice, both in experiments and actual use, have abundantly proved, and the account of the different journies and working of this engine, given in the course of this work will amply bear out these remarks.

No. 4.—Mr. M'Adam, in his evidence on this point, remarked that "the engine had a *very great power of traction; I was very much surprised at it.*"

The journies of Mr. M'Adam and Mr. Lamerton; the working to and from the collieries; and the other accounts of working as has already been shown, and may be seen further on, and under

cost, amply satisfy the conditions required by this and No. 7.

At the Agricultural Show at Salisbury one of these engines took a load of seven tons up an incline of 1 in 7 with the greatest ease.

At the Agricultural Society's meeting at Chester, the year after, it went up an incline of 1 in 3½, through a beanfield, without any inconvenience; but had no load behind, the purpose intended being to see if it could master such an ascent.

Col. Sir F. Abbott reported an instance in which one of these engines drew four large siege guns, weighing 28 tons, up an incline of 1 in 13 at Woolwich. On other occasions the engine has been up 1 in 8 and 1 in 10 at the same place, with a load behind, without any trouble.

The fulfilment of the remaining requirements will be seen to be completely satisfied, from the following accounts of the working of the various engines, frequently under my own observation; and also under cost of working.

It does not follow, however, that because an engine can be made to work in an unfavourable place, or over very bad ground, it should be made to do so. Such a course would be about as reasonable as opening oysters with a razor, because a razor *might* be used for such a purpose.

The true economy and secret in using steam power is to give it as great facilities as possible in its working, so as to get the most out of it for a given expenditure.

In June, 1856, a select committee, appointed by the Government, subjected one of these engines to various tests. The engine, weighing 9 tons, hauled a heavy siege gun (5 tons 12 cwt.), carriage and tender (2 tons 7 cwt.), and 16 men (say 1 ton 2 cwt.), from the Arsenal up Burrage road to Plumstead Common, and down the steep incline to Waterman's Fields, in return. The steepest part of the ascent is 1 in 10, and of the descent 1 in 8, or thereabout.

In going up Burrago Road, the wheels of the gun carriage sank from one to three inches in the shingle of which the road was made, a circumstance which greatly added to the draught.

The engine, attached by a rope to a gun of the same size, dragged the weight of eighteen tons triumphantly over a marshy bog, a result which all the artillery horses in Her Majesty's service could not have effected.

The above trial took place before a very numerous committee of Royal Engineers, and other practical and scientific gentlemen, appointed by Lord Panmure especially for that purpose.

Numerous other trials were made in different parts

of the country, all of which were attended with uniform success.

The following extracts are from a "Journal of a Trial of Mr. Boydell's Traction Engine on its Endless Railway, from Thetford in Norfolk to London, being about 85 miles, on Thursday, Friday, and Saturday, the 14th, 15th, and 16th days of May, 1857," made by Mr. M'Adam, of Bath.

The load consisted of articles which were to have been sent to London by railway, and the train of carriages which contained them was necessarily elongated by the requirements of the General Turnpike Acts, which restrict the weight of goods which shall be placed upon two or four wheels.

The Train was 95 feet in length.
The Engine was 27 " "
Together 122

| | Tons. | cwt. | qrs. |
|---|---|---|---|
| One Timber Waggon, $4\frac{1}{2}$ inch wheels . . | 5 | 7 | 0 |
| One Threshing Machine . . . . . . | 2 | 0 | 0 |
| One " " . . . . . . . . | 1 | 17 | 0 |
| One Waggon on $2\frac{1}{2}$ inch wheels, containing a spare supply of water (never used), coals, coke, iron castings, &c. | 4 | 0 | 0 |
| One Agricultural Engine (which was left at a farm, near Newmarket) . . | 3 | 0 | 0 |
| Eight people (three of whom were in attendance on the engine and one on the train) . . . . . . . . . . | 0 | 12 | 0 |
| Chains and heavy attachments to enable the waggons to draw each other | 0 | 5 | 0 |
| Together . . . . . | 17 | 1 | 0 |

On Thursday morning left Thetford, at 10.3; supply of coke, 10 cwts. 2 qrs. 12 lbs.; ditto of coals (14 bags), 8 cwts. 2 qrs. 24 lbs. Tank full of water; one ton of spare water; 10.5 A.M. started; 10.10 double power on in mistake, reduced to single. First mile up hill, 1 in 24; 11.6 down hill about 1 in 36, then up 1 in 15; this tried the engine, the driver not being acquainted with her power; 11.15, stopped to show engine; 11.17, on again; 11.22, stopped at Elden for water; watered by a draw-well, with a small bucket; 12.46 P.M. started round a right-angled turn in a 23 feet road without any difficulty; 1·15, stopped for horses; 1.16, started; 1.43, stopped for heated driving wheel (a new box had been put in that morning); the road had been loose and made of flints; stopped for want of steam; coke had been tried, and smothered the fire; it was found to be too slow in burning; very bad parish road but flat; 3.15, stopped for water, three quarters of a mile from Mildenhall, Suffolk; cleaned ash pan for the first time; crowds of people, many horsemen, and some gigs following us, riding and driving close to the engine; 5.30, steep bad road, over 1 in 18; engine very steady; about 2½ miles an hour; steering beginning to be affected at the inner, or No. 2 point of draught; all this time single power used; 6.10, stopped at the "Red Lodge" Inn; filled up water

$3\frac{1}{2}$ miles from Mildenhall; cleaned fire pan; 6.35, started from the "Red Lodge;" road very good, dry, hard, and smooth; 7.36, crossed railway arch up a gradient of 1 in 15, newly stoned with broken flints; the engine went very slowly, but did not stop; would not steer well; tended to the near water-course, and at last got into it. I stopped the engine to alter the power, when Mr. Boydell desired the single power might be continued, and he would get us out of the difficulty by altering (for the first time) the point of draught to that in a direct line with the driving wheel, or No. 1; the engine then went on, steering quite well and got out of the water-course; 8.15, arrived at Newmarket; went through the town, and left the train in a wide part of the road; returned to town with the engine, and placed it in the yard of the "Half Moon," a most awkward place to go into or out of with two horses in a waggon, as the entrance is narrow, crooked, and of a steep ascent. The engine went in and out without the least difficulty, although there were not six inches to spare at two points of a crooked turn. This distance is 22 miles, in consequence of going round to avoid an insecure bridge on the main road. We started at 10.5 A.M., arrived at 8.15 P.M.; time, 10 hours 10 minutes. Deduct actual stoppages, 3 hours 55 minutes; less stoppages than would have been necessary had tanks

existed, 20 minutes; actual mercantile time 6 hours 35 minutes, which is equal to 3 and 4-10ths of a mile per hour for one day. Coal used (including a little coke) 10 cwts. 14 lbs.; or about half a hundred weight to a mile. The coal was bad—the road generally on a rise, Newmarket being much above Thetford.

Friday, May 15th, 6 A.M.—In Newmarket. Got up steam, and repaired the axles of the thrashing machines, which being of wood were working badly all the day before. 7.15, started with the train. 7.56, a hill near the fourth milestone, nearly 1 in 9, the rest of the hill 1 in 12; about 1 furlong in length; not the least difficulty. 2½ miles per hour. Road very good. 8.30, stopped at Six-mile Bottom for breakfast, filled up water; road good, but very undulating: the railway people telegraphed our starting from here up their line. The train was diminished in weight by the loss of the agricultural engine of three tons. 9.15, started across the railway. Road excellent, much down hill; stopped at Bourne Bridge for water; there being no convenient place to water, the engine was detached from the train, and turned at right angles down an embankment at 1 in 4; then on the bank turned again short to the right into the river, where the tank being filled, the engine went through the stream,

and up the other bank into the road, and backing on to the train, started at 11.33. 12.53, stopped for dinner at Chesterford, and filled up water. 2.13, started from Chesterford. 2.50, stopped at Littlebury to show the engine. 4.18, Newport, stopped for water, backed into a yard for it; stopped four times for horses. 5.3, went on, stopped very often to fill up water, fearing a want of accommodation. Windmill Hill, very long and heavy, 1 in 15 in one place. 8.30, Bishop Stortford, put up for the night; turned off a 15-foot road at right angles, with the whole train, into the inn yard, which ascended steeply; stuck fast on a dung heap, the rear waggon overlying the turnpike road. Put on double power, and took in the whole train, dispersing the dung heap all round; a shout from the bystanders, who had made up their minds that she was fast for the night; broke the steering pole, and had it fished with iron plates.

Saturday, May 16th, 7.22, A.M.—Left Bishop Stortford. Spillbrook Hill, 1 in 12, road broken, engine tended to near water-course; altered point of draughts and went on; 8·20, stopped to change draughts back again, tightened bolts on engine, and looked it over; stopped at Harlow railway bridge, took off engine, and filled up water; took in 12 cwts. of good coals, 20 cwts. having brought us from New-

market, 41 miles, less than half a hundred weight per mile. Road excellent; Bishop Stortford to Harlow, six miles. Station-master said we had arrived in *half* the time they had allowed us to do it in. Put the drag on to the timber carriage before it had reached the top of the incline. The engine took it all over with ease, notwithstanding the drag. Engine driver quite acquainted with work and the engine; all went on smoothly; Harboro' to Epping, 7 miles; 12·20, P.M., Epping; watered and dined; road hilly and rough from Harlow, but hard and dry; weather very fine; the road telling on the shoes; the consumption of oil and grease great; 1·37, started from Epping, taking one passenger, who was anxious to see the engine work; left the engine at a pond to water, when the men, without orders, put on a new finger, in lieu of one broken; took in water; 1 tank full had brought us 9 miles of very bad road; the road through Epping Forest and into Woodford very bad; no level; gradients from 1 in 18 to 1 in 40; the road broken up all over, sandy and heavy, with half settled material (round flint gravel unbroken); 5·20, started from Woodford; 5·25, at the bottom of the hill in the street engine stopped, and, on coming up to it, saw two teeth broken out of the geared wheel, and the backward shoulder of the shaft saddle broken off beyond the bolts; 5·45, changed to the double

power to ease the saddle; the bolt of the lever of the double power came off; here I left the train within 200 yards of its destination, which was to be at Stratford. It was supposed the accident was caused by a momentary riding of the shoes from an improper bend in the new finger, but this was not confirmed by the engine driver, who must have felt the shock; he only saw the tooth fall, and then the bit of the saddle fall at his feet on the foot plate. The crank shaft was slightly bent at the same time, yet nothing appeared to derange the motion of the engine. The road was good and slightly down hill, and on a turn. I was looking at it from a short distance, but did not perceive any peculiar motion. The heels and toes showed the effect of 85 miles of flint road, and one end of each rail was worn at the corner ("in consequence of not being set in a direct line, this point was first touched by the wheel, and it just dented it down. On the top of the boiler there are two upright castings of iron, through which the working shaft went. I never could quite understand the reason for the rails being laid out of the direction of the route—it was a mere mechanical defect in the making of the shoe, and was not a necessary consequence of the principle of the construction of it. I felt in my own mind that I could have got rid of it if I had made the shoes.) "The fingers were in

some instances indented, but I do not think the actual loss of iron as much as would have been incurred on the shoes of the fourteen horses it would have required to draw the train. There was not any perceptible wear in any other part of the engine. The coals averaged half-a-hundred weight per mile, and the pace averaged three miles and a-half an hour. There was much less difficulty in descending hills and turning corners with a long train, than was anticipated."

It will be seen that Mr. M'Adam observed, "the consumption of oil and grease was great;" this he has since stated was owing to the heating of the boxes of the driving wheels, which from being put in in a hurry on the morning they started, were not perfectly true, and was a mere mechanical defect; but it not being considered desirable to delay the trial, the engine was sent off under great disadvantages for so long a journey.

The next journey made with one of these engines was that of Mr. Lamerton, superintendent of machinery at the Royal Arsenal, Woolwich, who in September, 1857, at the desire of Colonel Tulloch, superintendent of the royal carriage department, Arsenal, Woolwich, accompanied an engine and train from Thetford to Woolwich, a distance in round numbers of one hundred miles, and his

remarks and notes of the journey, in the form of a report to Colonel Tulloch, are given as follows, and they show in a very satisfactory manner what the power and capabilities of this engine will be when properly constructed:—

## TRACTION ENGINE AND ENDLESS RAILWAY.

Royal Carriage Department, Woolwich.
25th September, 1857.

SIR,—I beg leave to state that, agreeably to your instructions, I proceeded on Monday, the 7th instant, to Thetford, in order to accompany and make observations upon one of Mr. Boydell's Patent Traction Engines and Endless Railway, from that place to Woolwich, with a load of timber, along the turnpike roads, and have the honour to submit the following particulars, as the result of my observations:—

Tuesday Morning,—Started from the manufacturer's (Mr. Burrell's) yard with the engine, and went about half-a-mile out of the town on to a common, where two carriages, loaded with oak timber, and a van with tools, coals, &c.—the weight being 33 tons, 1 cwt., 3 qrs.—was hooked on to, and drawn off the soft turf, the wheels of the carriages being sunk in 6 inches, up an ascent of 1 in 20, on to the road. Moved on down a slight descent on a

tolerable good road: after travelling several miles, found one timber carriage axle bolt broken, thereby causing the end of carriage bolster to act as a very heavy break on the wheel, which delayed us a considerable time for temporary repair. It had now been raining fast some time, making the roads heavy. Stopped and changed gear from double to single power, and travelled at times at the rate of from 5 to 6 miles per hour; *turned a corner at right angles*, and went up a long hill, *gradient* 1 *in* 20, into Bury; *turned round the market place, and then a corner at right angles, in first-rate style*, with crowds of people following.

Wednesday and part of Thursday occupied in repairing timber carriages (they being old, and not strong enough for the load), and collecting the remainder of the load.

Thursday, left Bury St. Edmunds with the whole load, consisting of engine, 4 timber carriages, and van, the length of which was 182 *feet*.

The weight being—

| | Tons. | cwt. | qrs. |
|---|---|---|---|
| Engine | 15 | 0 | 0 |
| 5 Logs of Oak Timber | 18 | 7 | 0 |
| 4 Timber Carriages | 6 | 1 | 0 |
| 1 Van, with Tools, Coals, Men, &c. | 4 | 10 | 0 |
| Total | 43 | 18 | 0 |

Pressure 80 lbs. per square inch, on a chalk and flint road; passed several long hills; one of the feed pump-valves having broken, stopped to replace it; second valve broke, which obliged us to draw on to the road side and stop the night, to get them repaired at Newmarket.

Friday morning, put in repaired pump-valves, and drew off the turf on road-side in good style, with 57 lbs. pressure—the wheels being in a rut, and the turf soft from much rain having fallen during the night; passed over railway bridge—gradients *up ascent* 1 *in* 15—steam pressure, 75 lbs. Roads very heavy, it raining heavily all day. Stopped for water near toll-gate; waited to obtain some by water-cart from farm-house, having been misinformed; passed through Newmarket, and up hill near race-course—gradient 1 in 20; stopped for the night, all being wet through.

Saturday morning,—left Newmarket at 6·47, with 85 lbs. steam pressure. Passed up several steep hills, —greatest gradients, 1 in 17. Stopped to get water and breakfast. Altered gear to single power, and got up hill of heavy ground, and gradients of 1 in 30 with difficulty, *having only single power gear at work*, steam pressure—115 lbs.; altered to double power, to get up hill about three quarters of a mile long; gradients 1 in 30, steam 73 lbs. pressure. Stopped

and blew all the steam off, to adjust pump valves; got up steam again and went on; stopped at Audley End for the night.

Monday,—left Audley End, and drew off a bad piece of ground, the earth being very soft; passed up several hills; put in new pump valves at Bishop's Stortford. Went up a long circuitous hill—gradients 1 in 24—steam pressure, 105 lbs. Passed up another hill,—*gradients* 1 *in* 14. Stopped at Sawbridgeworth for the night, pump not working satisfactorily.

Tuesday,—got pump valves repaired, and left Sawbridgeworth at 12.21. Steam pressure, 90 lbs. Stopped at Epping for water. Roads heavy through Epping Forest, having been regravelled in many places, and a long hill,—gradient 1 in 30. Stopped near Woodford for the night, having travelled the last 2 or 3 miles in the dark.

Wednesday,—left Woodford at 12.3, as it was considered best to come through London early on the following morning. Passed over 200 feet of rough macadamized road, the whole of the train being in at the same time, with 73 lbs. pressure. Passed over another piece of rough macadam, about 300 feet, and up hill; near Leabridge, a great number of horses passing, caused many stoppages; turned into the Clapton road at nearly right angles; one-half of the

nave of one of the timber carriage wheels dropped off some distance from Cambridge Heath toll-gate, near which the train was drawn up very slowly and cautiously to stop the night, and get the wheel repaired.

Thursday,—started at 5.24, and passed through the toll-gate,—*the train was steered through very nicely, there being only just room to pass, and turning at right angles into the road to Shoreditch.* Went over the stone pavement without any slipping, till the train reached the rise on London Bridge. Stopped and put in clutch, to connect off wheel with axle, the only time there was occasion to use it during the journey. On account of the slippery state of the pavement, and *having only one skid on the timber carriage wheels* in going down the incline on the south side of the bridge, which is considerable, and the great weight pushing on the engine behind, caused the shoes to slip. The engine driver reversed the engine suddenly to stop the train, which partially broke two teeth out of one segment of the driving wheel, but did not stop it from going down the remainder of the hill; and by using old nail bags under the shoes or sleepers, went on without difficulty. It being market morning in the Borough, the train had *to pass through a great number of horses and vehicles of all descriptions, which it did*

*triumphantly without casualty;* passed on to the Dover Road and got off the pavement, having travelled at least over three miles of it. Went on rather slowly, on account of the teeth being partially out of the wheel, and not wishing to stop to replace the segment till reaching New Cross railway station, it having been arranged to wait there until 12 o'clock. A great number of horses passed the train both ways, many passing apparently without noticing it, but for some it was stopped. Arrived at New Cross at 8.28—put in new segment to driving wheel, and left New Cross station at 12.52, with 75 lbs. steam pressure, up-hill. Stopped on the Greenwich road to alter gear from double to single power; in consequence of the pinion fitting the shaft tight, considerable delay occurred. Started again, and came along the road at the rate of at least five miles per hour, and arrived at the lower dockyard gates at 3.4; disconnected the train—the gates not being wide enough, and the roads forming an acute angle, the train could not be turned in connected. The train was drawn in by the engine, which then left the dockyard, and arrived at the arsenal at 5.5.

Annexed, in a tabular form, is given the details of time, stoppages, gradients, water evaporated, steam pressure, &c.

The total quantity of coals consumed was 106 cwt.,

but allowing for moving and collecting the timber at Bury, extra lighting and re-lighting the fire, on account of the feed-pumps and for stoppages, say 15 cwt., will leave 91 cwt. for the journey, equal 102·432 lbs. per mile.

The water evaporated was 5571 gallons, equal to 55·989 gallons per mile.

The oil used 2 gallons, and the grease 25 lbs.

Number of men employed, 5—3 on the engine, and 2 to attend the timber carriages, &c.

The average rate of travelling was 3·1 miles per hour; but had the timber carriages been strong enough, it could have been at least 4·5. I would here remark that it was intended to bring a much heavier load, but fearing the carriages would fail, and stronger ones not to be had, it was thought best to lessen the load, which has proved to be considerably lighter than was supposed.

*The train was turned round all the bends and curves without detaching any of the carriages,* from leaving Bury until it reached the dock yard gates. I may here mention that the engine *was backed out of a yard at Bury, and turned round in the road in less than its own length.*

With respect to the general working of the Traction engine, *it was quite satisfactory*—did its work

*admirably and well*, and took the load up the steepest gradients, 1 *in* 14, at the rate of from 2 to 2½ miles per hour, with 95 lbs. steam pressure per square inch, *without any appearance of the sleepers slipping*, and I feel no hesitation in saying that it would have brought *double the load*, with the exception of some of the steepest gradients—the road being undulating all the way from Thetford to London. I would also state, with reference to the slipping that took place on the pavement, coming down the incline from London Bridge, that I do not think it would have occurred had the mats that were prepared been fixed to the sleepers, and more of the carriage wheels skidded.

*The delays on the road were not caused by anything in connection with the general arrangements or working of the Traction Engine and Endless Railway*, but in consequence of an error in fitting the feed pump valves, which should be so fitted as to leave the least possible chance of failing.

I would suggest that another pump might be attached, and when required work from the same eccentric rod, also fitted with suction hose to supply the cistern with water, from ponds or any other source.

The wear on the wheels, sleepers, or rails, *appears*

*very little*—principally on the ends of the rails, and that not much. The breakages on the whole journey, *which were quickly replaced,* being only 5 bolts, 1 stop, and 2 teeth partially out of one segment of the driving wheel.

Sergeant Squires, of the Royal Horse Artillery, accompanied me with the train from Thetford to Woolwich, rendering much assistance, in directing horses and vehicles; I also found him generally useful along the road, and very attentive.

I have the honour to be, Sir,

Your obedient Servant,

(Signed) W. LAMERTON,
Superintendent of Machinery.

To Colonel TULLOCH, Superintendent,
Royal Carriage Department, Woolwich.

## TABULAR FORM REFERRED TO HEREIN.

| Sept. 1857. | Number of Miles Travelled per day. | Time from starting to stopping. | Stoppages. | Actual Time Travelling. | Gradients. | | Steam pressure per square inch. | | | Gallons of Water Evaporated. | REMARKS. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Greatest. | Least. | Lowest. | Highest. | Mean. | | |
| | | H. M. | H.M. | H.M | | | Lbs. | Lbs. | Lbs. | Gals. | |
| 8th | 11½ | 7.55 | 4.20 | 3.35 | 1 in 20 | 1 in 26 | 49 | 110 | 83 | 732 | Stoppages caused principally by axle bolt of timber carriage breaking, shifting of timber, and filling up with water. |
| 9th | | | | | | | | | | | Occupied repairing timber carriages, shifting timber from one carriage to others, and loading remainder. |
| 10th | 7 | 4.58 | 2.40 | 2.18 | 1 in 26 | 1 in 28 | 75 | 107 | 92 | 464 | Part of day taken in completing repairs of timber carriages. Cause of stoppages—getting water, and the feed-pump deranged in consequence of the valves not being properly fitted, compelling the remainder of the journey to be deferred till the valves could be repaired. |
| 11th | 7½ | 5.48 | 3.4 | 2.44 | 1 in 15 | 1 in 48 | 75 | 100 | 81 | 502 | Considerable delay in getting water, having been misled where it could be obtained. Rained heavily all day. Roads very heavy. |
| 12th | 21½ | 12.20 | 6.1½ | 6.18½ | 1 in 17 | 1 in 60 | 57 | 115 | 90 | 1246 | Stopped 3 times to fill up with water. Roads very hilly. Feed-pump again deranged, in consequence of which, all the steam had to be blown off, and the fire put out and re-lit. |
| 14th | 15 | 10.32 | 5.40 | 4.52 | 1 in 14 | 1 in 30 | 45 | 110 | 85 | 722 | Principal cause of stoppages—lowering chimney to go under railway bridge, taking in coals and water, repairing couplings of timber carriages and derangement of feed-pump valves. Roads hilly. |
| 15th | 15½ | 7.49 | 2.36 | 5.13 | 1 in 21 | 1 in 32 | 37 | 100 | 77 | 846 | Started late, in consequence of getting pump-valves repaired. Stopped some time at the request of Sir Proby Cautley, to examine the action of the sleepers or shoes; also several times to get water, and frequently for horses, also for feed-pumps. Roads very heavy and hilly. |
| 16th | 8½ | 4.26 | 1.35 | 2.51 | 1 in 30 | 1 in 60 | 73 | 100 | 87 | 418 | Stopped to get coals and water; also a great number of times for horses, several hundreds passing, as the train got near to London. |
| 17th | 13 | 11.41 | 7.32 | 4.9 | | | 65 | 105 | 85 | 641 | Waited at New Cross, agreeable to arrangement, for several gentlemen to witness the train in motion. also stopped a considerable time in changing gear, the pinion fitting shaft tight. |
| Totals. | 99½ | 65.29 | 33.28½ | 32,0½ | | | | | | 5571 | |

In the month of February a report on this engine was made to the East India Government, by Col. Sir Frederic Abbott and Sir Proby T. Cautley, who had been requested by Sir J. C. Melvill, K.C.B., to examine its working and capabilities, and this report was ordered to be printed by the House of Commons, in April of the same year. The report runs as follows:—

*Return to an Order of the Honourable The House of Commons, dated* 22 *April* 1858;—*for*

A Copy "of the Report upon the Capabilities of Boydell's Traction Engine, made by Sir Frederick Abott, in February last, to the Honourable East India Company."

J. D. Dickinson, Secretary.

East India House, 29 April 1858,

BOYDELL'S TRACTION ENGINE.

Military College, Addiscombe,
11 February 1858.

Sir,—I have the honour to inform you that, agreeably to instructions conveyed in your letter, dated 23d October 1857, I have, in company with Sir Proby Cautley, attended one meeting of the Ordnance Select Committee, and one full trial of Boydell's Traction Engine.

2. Sir Proby Cautley having already made known to you very fully his opinions regarding this engine, has begged me to report on this occasion my individual sentiments. I shall, however, send this letter through his hands, in order that he may add any observations that may occur.

3. The engine experimented with, on Thursday the 4th instant, is one which when working under a steam-pressure of 120 lbs. per inch, is calculated at 37 horse power. *Having been constructed for agricultural purposes, and in the most enconomical manner*, it drives only one wheel (the "off-wheel"). At the Royal Arsenal, it took in tow four 8-inch guns, two mounted on ordinary, two on devil-carriages; the whole load being estimated at about 43 *tons*. This load it drew at the rate of about three miles per hour on level ground, and at about 2¼ miles up a steep hill, *part of which was inclined* 1 *in* 13. *Its power of draught was very great*; but, owing to its driving only one wheel, it was unmanageable with a load, as it could scarcely be turned to the right hand.

4. The experiment, in so far as regards *this individual engine* for general purposes of draught, must be pronounced a failure. But the powers and capabilities, as exhibited on Thursday, and on trials, reports of which I have seen with the Select

Committee, *inspire me with the greatest confidence in its final success, when the machinery shall be perfected to work both wheels together, or either wheel singly.* An engine so constructed and equipped with a train of carts of peculiar, though simple form, would be able to traverse *any country where an ordinary bullock-cart could travel*; and, being able to move continually at the rate of 3½ or 4 miles per hour, would perform journies of little less than 100 miles in the twenty-four hours. *An establishment of such engines and carts would enable Government to dispense with half the ordinary military force in India.* Seeing that troops could then be concentrated in *one-fifth of the time required* by even "forced" marches, such self-acting railways, though immeasurably inferior in speed to fixed railways, will be more generally useful for military purposes, as they will *travel in any direction, and will be safe from the designs of enemies.*

5. Prompted in these views, I urged the patentee to perfect one engine with train. He pleaded want of funds, having expended large sums in the invention as directed to agricultural purposes. He has, however, addressed to me a letter, extract from which I annex, proposing to complete, for the Honourable East India Company, a smaller engine with train of carriages to carry 120 men, at the cost of £680.

6. I feel no hesitation in recommending the Court of Directors to accept the offer, on the proviso that the engine and train shall be found to travel with ease and safety on ordinary roads and lanes. If successful, *it will mightily aid in the economical tenure of our Eastern Empire.*

I have, &c.,

(Signed) F. ABBOTT, Colonel.

Sir J. C. Melvill, K.C.B., &c.

*From Colonel Sir Proby T. Cautley, K.C.B., to Sir James Cosmo Melvill, K.C.B., Secretary, India House.*

31, Sackville Street,

*February* 12*th*, 1858.

SIR,—I have the honour of forwarding a letter from Colonel Sir Frederick Abbott, C.B., with whom, agreeably to the orders I received in your letter, dated 23rd October last, I attended the Select Committee at Woolwich, and also a trial of the Traction Engine and Endless Railway, as described by Colonel Abbott.

2. I may remark, in continuation of my letters to your address of the 17th September and the 25th October last, in the first of which I entered fully into the value of the machine, that I see no reason

of changing the opinion therein expressed. My views then (as they are now) were, "*that with a perfect engine the Endless Railway apparatus would, at the present time, be most useful in India for the carriage of troops, where there are neither railroads nor steamers in sufficient abundance available.*

"*It would be useful attached to arsenals and yards where the carriage of heavy material is required, and where speed is no object.*

"*It would be most useful in dragging weights over sandy and shingly beds of rivers, or where guns or heavy weights have to be dragged out of, or through heavy ground.*

"*As an adjunct, in fact, I look upon the Traction Engine and Endless Railway as possessing high qualifications.*"

3. I join with Colonel Abbott in the recommendation made in his sixth paragraph.

I have, &c.

(Signed) PROBY T. CAUTLEY, Colonel.

(True copies.) PHILIP MELVILL.

Towards the end of the same year one of these engines was taken over to the show at Londonderry. It drew six of the large four-wheel road spring waggons, belonging to the Enniskillen Railway Company, which were attached to it by means of a chain

running underneath, and through the whole length of the vehicles. The train, with the engine, measured 170 feet long, and proceeded on its *route* at the rate of three miles an hour; first through one street and then another, until its whole length filled portions of *three streets at one time,* the astonishment of the spectators reaching its climax. The first three waggons were laden with coals, ploughs, and cultivators; and the last three, being fitted up with seats, were literally crammed with people, who seemed delighted at the idea of being drawn on the common road by steam. The engine subsequently worked on M'Cormick's *slob* lands, and performed equal wonders there as on the common road.

During the months of March and April, 1859, an engine and train of five waggons (see frontispiece) were for some time employed in drawing coals from the Smithfold Colliery, belonging to Messrs. J. Gibson and Co., about eight miles from Manchester, into that town, and as I was engaged in assisting to carry out this affair, and examine the working of the engine and train, I am enabled to speak with confidence as to its power and performances, which excited a great deal of attention amongst scientific men and others interested in the use of steam power, who came from all parts of England and Ireland, as also from Scotland, to see its performances.

This engine had two horizontal cylinders, 7 inches in diameter, with 12-inch stroke, and had driving wheels 7 feet in diameter, with the endless railway fitted to them. The engine was so fitted that what is termed a double power could be used when coming to a hill, or greater power was required than could be obtained by the use of the single power. This power was only required when coming up from the pit to the turnpike road, through a narrow uneven lane, with a gradient of about 1 in 13, and a load including waggons of rather over 34 tons, as the single power was quite equal to any part of the road after the train was out of the before-mentioned lane; which, from the traffic of a great number of carts constantly going down or up, was in an exceedingly heavy condition, and very much cut up by their wheels. The water was carried in a tank suspended under it, which held water enough for a trip of about six miles, on an ordinary road, with the above load, or a distance of eight miles when light. The engine had the link motion reversing gear; and was usually worked at a pressure of 80 to 85 lbs. per square inch, using the expansion gear.

In the front of the engine, over the fore wheels, was a platform and seat, and the steering wheel and elevating screw, by means of which the water is maintained at or near a level, when going up or

down inclines, a plan of construction which showed its advantage both whilst working to the colliery, and also when going to Liverpool by road, and an engine thus fitted can go with safety into almost any position where wheels can be used, and which, without its aid, it would be exceedingly dangerous to attempt.

The journey to the pit, eight miles, usually occupied a little over three hours, including a stoppage of 12 minutes to fill up the tank, when within two miles of the pit, the water to be had there being totally unfit for use. The trip back from the pit, with a gross load of a little over 34 tons, was usually performed in about three hours and ten minutes, including 12 minutes stoppage for water, and the journey both ways might have been easily done in much less time, had it not been for the immense crowd of carts continually on the road, all drawing coal, and who, consequently, were disposed to put every obstacle in the way of the engine and train, by straggling across the road, so that there could be no room to pass, necessitating the speed of the engine, whether loaded or light, to be reduced to that of themselves, and it was only by bringing the train close behind them, and threatening to run over them, that they could be induced to make way and let the train pass, which they then did, amidst a choice selection of phrases

not to be found in "Johnson" or "Webster," and anything but gratifying to "ears polite."

I found that with a load of about thirty tons behind the engine, an average speed one-fourth to one-third greater than that of the loaded carts, could be maintained with perfect ease, and as each day the three men got more accustomed to the engine and train, in a corresponding degree was the speed of the train increased, and regularity of motion, and ease in management attained, until at last the train could be taken round corners at its usual speed, without stopping; the man attending to the waggons and break quickly getting quite *au fait* in his duties, which was rather surprising, as he had never seen anything of the sort before; nor was he in any way remarkable for his intelligence.

The road was undulating and crooked, some of the inclines being very long; but the heaviest on the road did not much exceed 1 in 45. Going into the coal yard was a sharp turn at right angles, with a gradient of about 1 in 30, which was on every occasion, whether the engine was loaded or light, easily turned without stopping.

The engine and train, a length of more than 100 feet, were repeatedly taken through the most crowded streets of Manchester at all times of the day, and in all directions, with the greatest ease,

and without the slightest accident, turning all descriptions of corners; and all who saw it were perfectly satisfied of its ease, safety, and utility, in working. On one occasion the engine and train were in three different streets at once!

The average consumption of coal was found to be under three-quarters cwt. per mile, grease not quite a quarter of a pound per mile, and the oil on each trip to the pit and back never exceeded one pint and a-half.

The *Railway Record*, of March 26th, 1859, in remarking on the working of this engine at Manchester, observes: "It may be asserted without fear of contradiction, that wherever there is an adequate amount of traffic, the advantage of Boydell's traction engine is beyond question. And here we may take the opportunity of drawing the attention of railway companies to the important services which this engine might be made to perform in bringing up heavy traffic (mineral) to the main line of a district, where the expense of contributing a branch cannot be entertained."

The *Manchester Guardian*, of the 19th March, 1859, after having examined the engine, says: "Although it weighs ten tons, there is no apparent injury done to the road over which it passes. Upon a road as good as Water-street, it can draw fifty

tons. It is readily managed, and turns without any difficulty."

After having worked some time from the coal pits, and been taken on numerous occasions through the streets; the engine and train of five waggons, to which were added two two-wheeled carts, on the 12th of May left Manchester for Liverpool, *viâ* Warrington, where they were finally shipped.

The engine and train, a gross load of 19 tons 15 cwts., forming a train of at least 130 feet in length, at 11 o'clock on the morning of the 12th May, 1859, was started on its journey to Liverpool, along the turnpike road *viâ* Warrington, where it stopped the night, and proceeded on the next morning *viâ* Prescot.

The distance of 18 miles to Warrington was performed in 6½ hours, deducting stoppages. The great bane of the journey throughout, was the want of knowing where water could certainly be obtained on the route, which caused many and more frequent stoppages to have been made than were necessary.

The other half of the journey, about 20 miles, to the railway yard at North Docks, Liverpool, deducting stoppages, was performed in 6¼ hours. A very interesting account of this journey, written by one of

the engineering gentlemen who was with the train throughout the entire trip, will be found in the *Artizan* for July, 1859; I was also with it, and can bear testimony to the accuracy of the statements contained in it.

In the same year a Traction engine and five waggons, ordered by the Government for the Bombay Presidency, was exhibited in Hyde Park, to show its facility of management and utility where no railroads exist, and also that it could be used without injury to the ground it passed over. The following is extracted from the *Times* of August 13th, and is the general opinion held by all those who have had an opportunity of seeing it at work:—

"Boydell's Traction Engine.—During the last two days the capabilities of this admirable road locomotive have been publicly tested in Hyde Park. The endless railway acted with the most perfect satisfaction, quite bearing out what has been before stated, that the engine could not only travel over the worst roads, but that the roadway itself is actually improved by the equal and broad compression of the rails. Attached to the machine yesterday were five powerful waggons, specially made for the purpose, and all of which, by removing a pin or pivot from between the two leading wheels, are enabled to follow every turn of the engine with a serpent-like movement, which

gives the utmost freedom and flexibility to the whole convoy. Yesterday, more than once, the whole train turned in less than half its length, and that, too, in passing over grass and uneven ground. The indentation made by the passage of the wheels was certainly no more than would have been made by an ordinary coal waggon. After two o'clock 160 soldiers of the Guards were in attendance, and rode in the waggons, and with this load the whole train was taken easily across the level parts of the park at the rate of six miles an hour. The results of the trials were, in the highest degree, satisfactory, and seem to leave no doubt whatever that over the rough roads of India, during the summer season when the rivers are dry, the engines will be of the utmost service in facilitating the transmission of merchandise. For military purposes, such as getting up guns and siege stores, an engine of this kind would prove an invaluable auxiliary."

The reports of Colonel Sir Frederic Abbott, and Colonel Sir Proby Cautley, show their opinion of the value of this invention, which they have arrived at only after having seen it actually put to very severe tests.

Lord Stanley observed one night in the House of Commons, "that Government was perfectly satisfied with the principle of the Traction engine, and had

recommended two to be sent to Calcutta, and two to Bombay for a trial," one of which is already gone, and the others are in course of construction.

I was with this engine and train both days, and also on several other occasions at Acton, where various trials and experiments were made, so as to enable the men who went abroad with it to become thoroughly acquainted with its principles and management; no difficulty of any kind was experienced, the men soon understood their duty, and were quite equal to any work that the engine and train could be called upon to perform.

Of the utility of these engines and trains for moving troops, stores, &c., in the interior of India, there can be no doubt, especially when it is remembered that, in comparatively tranquil times, we generally lost *seven* men on the march in that country to one on the field of battle. Had these engines and trains been properly established in India at the time of the mutiny, each of them could have taken 300 soldiers, well armed, from 60 to 80 miles in the 24 hours, when they would have been fresh and fit to fight, instead of dying with fatigue on the route. The remarks contained in the reports of Cols. Sir F. Abbott and Sir P. Cautley fully bear out the truth of this.

The *Civil Service Gazette*, of the 28th August, 1859, in a leading article on developing the latent

wealth of India, gives a great deal of attention to this engine.

During the trials and working to and from the colliery at Manchester, the engine and train attracted the attention of Mr. Brunlees and Mr. E. B. Webb, two well-known civil engineers, who are extensively engaged in railways in the Brazils, and so convinced were they of the power and utility of these engines for certain purposes connected with the railways in that country that they had one constructed at Manchester, and at the end of 1859 it was completed and tried, and performed its work in the most satisfactory manner.

It went from Manchester to Oldham, a distance of about eight miles, with a train of six waggons, each loaded with 3 tons of iron, equal 18 tons, the weight of the waggons about 2 tons each, equal 12 tons, or a total of 30 tons. It was taken through the streets of Manchester, proceeding at the rate of between two and three miles per hour, turning sharp corners with facility and accuracy, answering to the steersman with wonderful promptness.

The steep hills at Oldham were ascended at a pace of about two miles per hour, and one of the inclines mounted had a rise of about 7 inches in 10 feet, or 1 in 17.

Here again, in the hands of a driver and steersman

who had little or no previous practice, the engine and train were easily managed, and safely taken through the crowded streets of Manchester without accident, and the steep hills on the road were easily surmounted. So highly is the Traction Engine and Endless Railway esteemed by the British Government, that one of them was sent as a present to His Highness the Pacha of Egypt, in return for some service he had kindly rendered to the government, and an account of the presentation to the Pacha will be found in the *Artizan* of February, 1860, which will no doubt prove interesting.

## COST OF WORKING.

In going into this part of the question care has been taken to give *facts,* it having been asserted by certain eminent engineers that there is *"no economy in the employment of steam for hauling heavy loads on common roads,"* an assertion, the truth of which I utterly deny.

Facts, it should be remembered, are stubborn things, opposed, as they may be, to the theories of men of supposed ability in some matters; and if I shall fail to show by *facts* that there is a very great economy in its use, especially where a regular traffic is to be maintained, then will those engineers be borne out in their dictum.

The transit upon turnpike roads may be divided into three descriptions—viz., first, heavy waggons for the conveyance of bulky or heavy articles; second light vans or carts for the conveyance of light goods; and, third, coaches for the conveyance of passengers. The heavy stage waggons travel at a rate of two, to two and a-half miles per hour. The

average cost of conveyance by this mode of transport, is *7d.* to *9d.* per ton per mile; the average being *8d.* per ton per mile, at the rate of two and a-half miles an hour. By the light vans or carts, travelling at the rate of three to four miles an hour, the cost of conveyance of light goods will average 1*s.* per ton per mile, at the rate of four miles per hour. In stage coaches, at the rate of nine miles an hour, the cost of conveyance is 3*s.* per ton per mile. In Scotland and Ireland, where the roads are made with broken stones, and where the practice is to use one-horse carts, the work performed by horses may be taken at 25 cwts., exclusive of the cart. But in England, where waggons are used, and the roads are not so hard, the work of horses may be taken at 15 cwts.

In the latter case, the average cost is about *9d.* per ton per mile, including wear and tear of carts, and the wages of the drivers. In some parts of the country the cost is *6d.* per ton per mile, but in other parts, as near London, it is 1*s.*

The expense of horse power has been variously estimated, at *6d.* per ton per mile, *9d.* per ton per mile, and 1*s.* per ton per mile; and I am informed by Samuel Hughes, Esq., C.E., F.G.S., that whilst he was engaged on the Holyhead Roads, under Telford, the engineer, that of the thousands of tons

of material used, and which were carted by the farmers, they *never paid less than 9d. per ton per mile*, and that 6*d*. per ton per mile was almost never heard of.

In order to show the great saving that arises from the use of steam, no plan can be more satisfactory than the case of the conveyance of a given number of tons per day, a given distance, by horses and steam; and as the horses could not do, say, twenty-five miles per day, six days per week, we will limit them to a load of one ton each, over that distance, the load to be moved each day being twenty tons net weight, horses going four days a week, and the engine taking twenty tons per day, also four days per week.

If we set down the capital to commence, with twenty carts, horses, and harness, at £1,200, we shall not be far off the mark; for the steam engine and five 4-ton waggons, we will say £1,500—or one-fourth more for steam—bearing in mind, however, that the same expenditure for steam would as easily move 30 tons as 20 tons, if required. In the estimates of cost of working nothing is charged for turnpikes, as they ought, in these vaunted days of progress, free trade, and liberalism, to be, and will be ere long, at least equal.

Here the great advantage of steam begins to show

itself, inasmuch as whether these 20 horses are working or not *they must eat*, and it does not appear that the cost of them can be less than £20 per week, or 3*s*. each per day; when not working equal to £3 per day, or three days at £3, equal £9.

If we give each driver two carts, and each man 2*s*. per day wages, we shall have £1 per day for men, and £3 per day for the horses, or £4 per day, so that seven days per week at £4, equals £28 as the cost of moving 80 tons per week 25 miles, by horse power.

The daily expense of moving 20 tons 25 miles per day by steam will stand thus :—

| | £ | *s.* | *d.* |
|---|---|---|---|
| Engine, including coal, wear and tear, oil, grease, &c., per 25 miles . . . | 3 | 0 | 0 |
| Wages of Driver, Steersman, and Breaksman . . . . . . . . . . | 0 | 12 | 0 |
| | £3 | 12 | 0 |

So we have £3 12*s*. per day as the expense of taking 20 tons 25 miles by steam, or 6 days at £3 12*s*., equal £21 12*s*. per week, there being no work done on the Sunday, and deducting the cost of steam the two days the engine is not working, but reckoning the wages of the men, it will be £21 12*s*. less £6, equal £15 12*s*., as the cost of drawing 80 tons per week over 25 miles, a saving in working expenses equal to £12 8*s*. per week, as compared with horse labour, or say £580 per annum, which we

will call £500. The wear and tear of waggons is not included in this, as it may be considered that it could not in any case equal that of the horse-power arrangement, even if two-horse waggons were used instead of one-horse carts, but at any rate we may call them equal.

From observations on the work actually performed by horses on several railways, the greatest effect produced by them is found to be 12 tons gross, drawn 20 miles per day; and the net weight of the goods carried will be eight tons over 20 miles per day by one horse, or 160 tons one mile at the average velocity of two miles per hour. The expense may be taken at 2*d*. per ton per mile.

On one of the railroads, the horses were very large and heavy, and the distance was 2156 yards or 396 yards more than a mile over which each horse went eight times a day, being in all about 19 miles. There were four horses regularly employed, but it was found necessary to keep a spare horse to give the others alternately a day's rest, so that in fact five horses were kept to perform the constant work of four horses effectively.

A railroad is peculiarly adapted to show the power of a horse, as he is continually employed in overcoming the same resistance; and the inclination of the road in general, has little effect upon the

power required to overcome the gravity of his own weight.

The power of a horse, or that part of his muscular exertion which in travelling he is capable of applying upon the load, has been variously estimated by different authors. It is not the force he is capable of exerting at a dead pull, or for a short period by which we are to judge of or estimate his strength; it is what he can *exert daily and day after day for a long period* without injury to his physical powers, that we are to take as the criterion for practice.

On canals a horse will draw a boat containing 25 tons of goods over 16 miles per day at 2½ miles per hours:—this is equivalent 400 tons of merchandise carried one mile per day or 2½ times as much as on a railway. It is stated that the actual expense of transporting goods by canal, is only one half-penny per ton per mile, including boat hire, steersman, wages and horse-power.

The heavy canal boats which are dragged at the rate of 2½ miles per hour, and which carry 20 or 21 tons of goods, weigh six tons and a half; and boats carrying 24 tons of goods may be taken at nine tons weight; these will give the useful load about 75 per cent. of the gross load.

In calculating the cost of conveyance on railways by horses, the driver and horses are estimated at

7*s*. per day, and the performance 280 tons conveyed one mile, or one-third of a penny per ton per mile; adopting the same estimate for the canal, we have 858 tons conveyed one mile for 7*s*., or nearly one-tenth of a penny per ton per mile; or making the same allowance as in the case of railways, we have the cost of haulage on canals as equal to ·123 of a penny per ton per mile.

Mr. Graham states that the contract price paid by the carrying companies for the trackage of heavy goods boats along the Forth and Clyde, and the Union Canals between Edinburgh and Glasgow, a distance of fifty-six miles, is 21*s*. The entire cost of conveyance by canals varies in almost all the different canals in the country, dependent, of course, on the first cost of formation, and the quantity of traffic upon each of them. The general cost may be taken at about 2*d*. per ton per mile for goods; coals, and other heavy minerals being conveyed at a less rate, or about 1½*d*. per ton per mile.

The expenses of working the traction engine for agricultural purposes has been found to average as follows: coals, 15*s*. per day—but these vary in price; driver, 4*s*. 6*d*.; steerer, 2*s*. 6*d*.; four ploughmen, and one extra, at 2*s*. each, equal 10*s*.; wear and tear, oil, &c., 10*s*.; fetching water, 3*s*.; total, £2 5*s*.;

which in ploughing heavy land, as at Farningham, gives an average cost of 5*s.* 6*d.* per acre, and on light land 3*s.* This cost, it is assumed, gives a result of eight acres per day on heavy land, and more on light. The consumption of water averaged about forty gallons, and coal one-half to three-quarters cwt. per horse power per day, and this for twenty horse power gives from half to three-quarters of a ton of a ton of coals for the four ploughs, performing eight acres per day. In trench-ploughing a small field with two of Cotgreave's trench ploughs, drawn by the engine by means of chains, working about twelve inches deep, at the rate of five acres per day, the cost of engine and attendance was 30*s.* per day, or 6*s.* per acre. The work was executed in a very superior manner, giving great satisfaction, and was valued by the market gardeners in the neighbourhood at 30*s.* per acre.

On another occasion this same engine was ploughing at Hanworth, to a depth of nine inches, at the rate of one acre per hour, or ten acres per day. Practical agriculturists who were present estimated the value of the work done at 20*s.* to 24*s.* the acre, while the actual cost of engine and attendance was 4*s.* 6*d.* per acre. Throughout the provinces the expense, on the average, of such ploughing as is

done by the engine, would be about 16*s.* per acre, instead of 20*s.*, as in Middlesex, but even this would give a profit of over £4 per day in favour of steam over horses, a profit which would redeem the first cost of the engine in less than a season.

The cost of haulage by these engines on common roads has been found, after numerous experiments and continued working, with an average net load of 20 tons, *not to exceed 3d. per ton per mile.* The first trip in which an account of coal, &c., was kept so as to give some certain data for calculation, was that of Mr. M'Adam, from Thetford to London, a distance of 85 miles. In the account of this journey no particulars as to the nett weight, or "load," are given, but it will be assumed that it was 17 tons net, which the engine would easily have brought, including the weight of the vehicles, at a trifling addition to the present cost of the journey.

We find that there were three men to the engine and one man to the train—their cost will be—driver, 4*s.* 6*d.*; steersman, 3*s.* 6*d.*; man for train, 3*s.*; odd man, 3*s.* per day; 14*s.* per day wages; this journey occupied three days; we have £2 2*s.* for wages. The coal burnt was 43 cwts., which, at 1*s.* per cwt., equals £2 3*s.*, wear and tear on 85 miles, at 1*s.* 6*d.* per mile, equal to £6 7*s.* 6*d.*; the consumption of oil

and grease was stated to have been great. Mr. Lamerton, in his journey of eight days actual working, used 2 gallons of oil and 25 lbs. grease, so, if his consumption be *doubled*, it will give a liberal allowance, and will stand thus—4 gallons oil at 5*s*. per gallon, equal £1, half cwt. grease at 10*s*. per cwt., equal 5*s*. The total cost of the journey will therefore be:—

| | £ | *s*. | *d*. |
|---|---|---|---|
| Wages for 3 days | 2 | 2 | 0 |
| Coal | 2 | 3 | 0 |
| Wear and Tear | 6 | 7 | 6 |
| Oil and Grease | 1 | 5 | 0 |
| | £11 | 17 | 6 |

or say £12, as the cost of drawing 17 tons over 85 miles; equal to, say, 14*s*. 2*d*. per ton on 85 miles, or 2*d*. per ton per mile.

By horses this would have cost, at the *minimum* rate of 6*d*. per ton per mile, £36 2*s*. 6*d*.; if at 9*d*. per ton per mile, £54 3*s*. 9*d*.; and, at 1*s*. per ton per mile, £72 5*s*.; taking it at the sum of 6*d*., there is a net saving of £24 2*s*. 6*d*. by the use of steam; and if we *double* the cost of the steam, making it £24, we still have a saving of £12 in its favour, no inconsiderable sum, where a large amount of tonnage has to be moved.

The next journey was that of Mr. Lamerton, from

Thetford to Woolwich, a distance in round numbers of 100 miles. It is seen that the train consisted of:—

| | Tons. | cwt. | qrs. |
|---|---|---|---|
| Engine . . . . . . . . . . . . . . | 15 | 0 | 0 |
| Five Logs of Oak Timber . . . . . . | 18 | 7 | 0 |
| Four Timber Carriages . . . . . . . | 6 | 1 | 0 |
| One Van, Coals, Tools, Men, &c. . . . | 4 | 10 | 0 |
| Total . . . | 43 | 18 | 0 |
| Deduct Engine . . . . . . . . . . | 15 | 0 | 0 |
| Gross Load . | 28 | 18 | 0 |
| Deduct Van, Waggons, Men, &c., say, . | 8 | 18 | 0 |
| Net Load . . | 20 | 0 | 0 |

We find that there were three men to the engine and two to the carriages, and, at the wages in Mr. M'Adam's journey, gives 17*s*. per day for wages. As this train was nine days on the road, we have the sum of £7 13*s*. as the amount of wages for the trip. The coals used amounted to 106 cwts, which, at 1*s*. per cwt., gives £5 6*s*.; wear and tear, at 1*s*. 6*d*. per mile, £7 10*s*.; oil, 2 gallons, at 5*s*., equal 10*s*.; grease, at 10*s*. per cwt., equal 2*s*. 6*d*.; therefore the total cost will stand thus:—

| | £ | *s*. | *d*. |
|---|---|---|---|
| Wages, at 17*s*. per day, 9 days . . . . . | 7 | 13 | 0 |
| Coals, at 1*s*. per cwt., 106 cwts. . . . . . | 5 | 6 | 0 |
| Wear and Tear, 100 miles at 1*s*. 6*d*. . . . | 7 | 10 | 0 |
| Oil and Grease. . . . . . . . . . . . | 0 | 12 | 0 |
| | £21 | 1 | 6 |

Or say £22 for the trip, or a fraction over 2¼d per ton per mile. In this case, horses at 6d. per ton per mile, would have cost for the 20 tons, £50 against £22 by steam; a saving of no less than £28 on the journey.

In spite of an improper train composed of waggons that would hardly bear the strain of thė journey, with faulty pump valves, which gave more trouble in this trip, than they should have done in ten years; *with an engine not made specially for haulage purposes, but partly for agricultural use; in fact with everything to prevent a straightforward trial, it is seen that the cost of the work done did not amount to half of what it would have cost by horse-power.*

It appears, 1 cwt. of coals took the train one mile; one quart of oil was used for 11 miles, or 1⅜ mile per ¼ pint; and the grease consumed, ¼ lb per mile; and the above is a very close approximation to the results obtained under my own observation. These engines have, up to the present time, been constructed almost entirely with a view to agricultural operations, so that they have not given such good results as if they had been made expressly for drawing and fitted with a train adapted for such puposes, as is now supplied with them.

There can be no doubt that the future working of these engines will be far more economical, inasmuch as there is now a decided opinion that they shoudl

be first made to work well on the roads, and that *then* the agriculturist will not be long in finding out their utility for other operations.

Mr. Gordon, in 1836, in his treatise on Elemental Locomotion remarked, "When steam-power is once established on the roads, it will not be long before it reaches the fields."

The following are the average results of the working of the engine and train to the collieries near Manchester; but as there was only a load *one way*, the results are not so good as if we had loaded *both ways*. The journey to the pit—8 miles—was performed in 3 hours and 5 minutes, including 12 to 15 minutes stoppage for water. The five waggons weighed 12¼ tons. The return journey, with 4½ tons of coal in each waggon, equal 22½ tons coal; waggons, 12¼ tons, equal say 35t ons, was performed, including 12 to 15 minutes stoppage for water, in 3 hours 10 minutes. The coal burnt was ¾ cwt. per mile; oil, less than ¼ pint; grease, ¼ lb.; wear and tear at 1*s*. 6*d*. per mile.

This gives the cost of working the engine and train as follows:—

| | £ | *s*. | *d*. |
|---|---|---|---|
| Wear and Tear, 16 miles at 1*s*. 6*d*. . . . . | 1 | 4 | 0 |
| Coals, at 7*d*. per cwt. . . . . . . . . . | 0 | 7 | 0 |
| Grease, 4 lbs., at 10*s*. per cwt. . . . . . | 0 | 0 | 4½ |
| Oil, 1½ pints at 6*s*. per gal. . . . . . . | 0 | 1 | 1½ |
| Wages—Driver, Steersman, & Breaksman | 0 | 11 | 0 |
| | £2 | 3 | 6 |

Now, the above shows the cost of moving 22 tons over 8 miles, to be at the rate of 5*s*. 5½*d*. per mile for the whole load, or a fraction under 3*d* per ton per mile. When compared with the present price of 3*s*. 4*d*. per ton, as shown by Mr. Gibson, to be at present charged for horses, or 3*s*. 1½*d*. if we deduct the toll, it is evident that even under the disadvantage of having to go 8 miles one way without a paying load, there is still a very considerable economy in the use of steam as compared with horses for this purpose.

The trip from Manchester to Liverpool *viâ* Warrington 38 miles, stopping the night at the latter place occupied two days; and the load behind the engine of the waggons, carts, spare gear, coke, &c., was equal to 19 tons, 15 cwts on leaving Manchester. The coke used on the journey of 38 miles, including getting up steam, was a little under 1 ton, this gives a trifle over ½ cwt per mile, the road being pretty level, and in a good and dry condition. The oil used did not exceed ½ gallon on the 38 miles, or less than ⅛ of a pint per mile. A small quantity of grease was used, which helped the oil.

Mr. Gibson, of Manchester, who has been thirty-two years engaged in collieries, says—"We are carting now from 500 to 1000 tons a-week from the colliery, that is what we bring by cart, and we bring other coal by canal. My judgment is, that we

can bring coals by means of this engine for the cost of the engine and wages, and coal for the eight miles, at about 6*d.* per ton; we are paying 3*s.* 4*d.* per ton for carting (at page 138, in his evidence he says '3*d.* and 4*d.*,' evidently meaning this), and within a circle of two miles from us, there are six other collieries situate as we are. The 3*s.* 4*d.* includes everything; the 6*d.* per ton would not include tolls; the toll is 3½*d.*; I merely put down 6*d.* per ton for capital, for the mens' wages, the coal, the capital sunk in purchasing the engine, and the dead stock; I think that would amply pay all those expenses, and I put down the toll at 3*d.*, if drawn by this. I consider that the engine ought not to pay anything like what we are paying now, *because it does not damage the road.*"

Mr. Hamilton, of East Acton, who has used one of these engines a great deal, gives the following results of his own experience:—" I am convinced that, with a proper engine, from 1000 to 1500 miles may be performed with very trifling repairs, particulary to the shoes, for they would only require new rivets, bolts, and the false toe pieces. During the time I was working the engine I made calculations as to the expense of conveying a ton of goods per mile, and found it to be about 2*d.*, that is, if you can load both ways. Two 6½ or 7-inch cylinders will take 15 tons 20 miles in a day for 52*s.* 6*d.*, which is a little over

2*d.* per mile per ton; viz., driver, 3*s.* 6*d.*; steerer, 2*s.* 6*d.*; man for train, 2*s.* 6*d.*; coals and oil, 14*s.*; interest and wear and tear, 30*s.*, equal 52*s.* 6*d.* In ploughing and scarifying, the engine has travelled about 521 miles, taking it at 3 miles to the acre; and we consumed 1¼ cwts. coal per acre, about 10½*d.* per acre." These results agree pretty nearly with those of others who have tried its working, and if 3*d.* per ton per mile is taken as the cost, it will be a fair estimate for working expenses and contingencies.

To bring out the full economy of steam power, it should always draw a paying load, and if it goes one way empty and brings a load the other, it will not give such great results as if it loaded both ways, but it is, under either circumstance, *far cheaper* than horse power, only requiring the wages of the men to clean it when idle, whilst horses require attendance and food whether *working or idle.*

The expense of working traffic by steam power will vary in different districts, according to the price of coals and the rate of wages; but the price of coals has been taken at £1 per ton in all the estimates, excepting that of the colliery at Manchester. In foreign countries, where both coals and labour are dear, the saving between haulage by animal power and by these engines will be greater in proportion than in this country, because it will enable them to perform

work that they are now unable to do with any expenditure of animal power; for instance, they are scarcely limited either to bulk or quantity moved at a time by the use of steam, which is not the case with animal power; and thus larger pieces and quantities can be taken with ease and fewer attendants, at a corresponding saving in cost of wages, and the gain of being able to do what before was impossible.

Two ordinary single cylinder portable engines, mounted on wheels fitted with the endless railway, so as to be driven by the engine, and having a horse in the shafts to steer them by, have been running for nearly two years, going about the county of Suffolk, drawing a thrashing machine, and working for hire nearly every day. One has cost up to the present time, for repairs of the endless railway £5, and the other £9; the larger sum being caused by the engine travelling longer distances (frequently 20 miles a day), and having done more work. These engines were started by Burrell, of Thetford. They are much preferred to the ordinary portable engine, and there is no doubt they will be found very useful and efficient.

The engines, whose performances have just been analysed, have been only working with a net load of 20 *tons*, and if it be remembered that an engine, drawing 30 *to* 40 *tons net*, only requires the same number of men, and the increased cost in working

between it and the 20-ton engine is almost entirely in the coal consumed, which bears a very small proportion to the work done; it will be evident, if the 20-ton engine gives such a profitable return upon the outlay, the 40-ton engine will be found to give a better; and it is here that the great superiority of steam traction becomes so strikingly apparent.

In regard to the cost of conveying passengers by steam, Mr. Hancock states that one of his steam coaches, carrying 22 passengers, would cost £1500. He also states that he ran his engine a mileage of 4,200 miles (712 trips), and carried 12,761 passengers, with a consumption of 55 chaldrons of coke, or less than 2*d.* per mile, his coke costing 12*s.* per chaldron; he got 76 miles from each chaldron burnt, and his total expenditure for coke was £33.

When running from Moorgate Street to Paddington and back, a distance of nine miles, he used four bushels of coke, or less than half a bushel per mile; and the time occupied, including numerous stoppages to take up and set down passengers, obtaining a supply of water and fuel, averaged one hour and ten minutes.

Each of his carriages was on an average five hours seventeen minutes running per day, and one ran four months without any intermission; and they used to

ascend Pentonville Hill, which has gradients of 1 in 18 and 1 in 20, at from six to eight miles per hour. In the report of Mr. James Stone, who acted as engineer to Sir Charles Dance's steam coach, one made by Gurney, which was running between Gloucester and Cheltenham, it is stated that in four months the carriage made 396 journies of nine miles each, equal to 3,564 miles, and carried nearly 3000 passengers; using 130 chaldrons of coke, costing £78, equal to 12*s.* per chaldron, or 4*d.* per bushel; but as one-third of this quantity was stated to have been burnt in "exercise and experiments, when not running," we have 86⅔ chaldrons as the quantity actually used in going 3564 miles, or about 40 miles per chaldron; making his expenditure for coke £52. The cylinders of this engine were 8 inches in diameter, with 18 inches stroke, and the average steam pressure 100 lbs.

It has been shown that Hancock run his coaches for four months without intermission; and if such things could be done in those days, when perfection in workmanship, tools, &c. was, so far from its present position, it would be interesting to know why at least as good results should not be obtained now, in those places where it would be advantageous to employ them.

Now that practice has removed all doubts of

the economy, safety, and superiority of steam on common roads, when compared with horse power, and proved its capability for this purpose; steam locomotion on common roads can no longer be considered unworthy the attention of the capitalist, though most persons have long thought the reverse. On this head, Farey observes, "I do not consider that it is now a question of theory; *for the practicability I conceive to be proved.*"

In order, however, to carry it out *profitably and usefully*, and seeing how profitable and useful it may be made, it must be remembered that steam traction requires capital, skill, and judgment, to be employed *in a more eminent degree than has yet been the case,* so as to enable this most interesting and important branch of mechanical science to be carried out properly, and prevent disappointment and want of success. From these causes, as much as anything, steam locomotion on common roads has not progressed in the ratio it should have done, and its importance deserves.

The *Foreign Quarterly Review*, in speaking some years since on this subject, remarked,—"The failure which has hitherto attended all attempts at the steam carriages, it is right to say, has arisen *not from any necessary incompatibility between the nature of steam and the particular application of its power, but from*

*the deficiency of the inventions in some of the great elements of structure, that are essential to its success.* We may therefore still look forward to the *substitution of its use for horse power, in bringing about a great and beneficial change* in the moral, political, and commercial state of the empire."

It should be remembered that the great feature of Boydell's engine is *light pressure on a large surface,* and the entire absence of any friction, or rolling or slipping motion of the shoes. It is at once evident that the tendency of this principle on common or bad roads, is to *compress and solidify, by a steady downward pressure,* whatever material or substance it passes over; and its effects, where a heavy engine has gone over a newly macadamized road, are of a most beneficial character, as it produces *a solid even surface,* tends to level and depress any unevenness that may exist on its route, thereby enabling a heavy load to be drawn behind with ease, and thus proves, in the words of the *Artizan,* "that road locomotion, without injury to the roads, is here most perfectly and efficiently attained."

# HISTORY AND PROGRESS
## OF
# STEAM ON COMMON ROADS
## IN THE
# UNITED STATES.

The employment of steam instead of animal power for the haulage of loads and conveyance of passengers on the common roads of the United States, had attracted the attention of numerous enterprising individuals, at a tolerably early period in the history of steam coaches, as will be seen in the following pages; and a tolerable amount of success attended the efforts of these early pioneers in the science of steam on common roads; but the ill success attending the efforts of those English engineers and others who had tried it in that country, and the absorbing attraction which railways at that time began to present, diverted most of the attention of those who could have enhanced its success, to other apparently more lucrative channels.

It has since proved that the English engineers and

capitalists, who had practically demonstrated the perfect capability of them on common roads to fulfil all that could be desired for economy and profit, were obliged to give up their attempts to introduce the system, not because of its mechanical difficulties,—these they had triumphantly surmounted,—but in consequence of the fierce opposition they met with in all directions, both from the hands of the ignorant and the learned man, and also from others whose common sense should have produced other results; these persons were enabled, from their influence in the British Parliament, to impose what are rightly termed "prohibitory" tolls on steam carriages and engines, and thus have utterly prevented their use in that country; and, what is more surprising, with all their outcry about "free trade," &c., these disgraceful tolls are still suffered to remain in force.

Attempts are being made in that country to reduce these prohibitory tolls to a fair and equitable rate; and the system of haulage by steam instead of animals on the common roads is again attracting the attention of practical men, and if the system is fairly tried, it cannot fail to become of universal employment. The British Government seems well disposed towards the use of steam engines for haulage purposes, from the fact of its employing them,

and also from having sent a "Boydell" Traction Engine as a present to the Pacha of Egypt.

In the United States steam haulage on the roads of the country is attracting a great deal of attention, but from the general diversion up to the present time, of the money of capitalists into other channels, it has not received so much encouragement as it deserves.

At the time of the experiments of Gurney, Hancock, and others in England several Americans attempted steam locomotion on roads of infeiror quality. The best roads were gravel, with hills as steep as 1 in 12, and the ordinary roads were of such earth as could readily be obtained, and with hills of natural slope, or nearly so.

To overcome such difficulties as these, the best carriages would have been necessary; and it is therefore no discredit to the general project, that these early attempts did not succeed, especially when it is remembered that our present splendid locomotive ships did not then exist.

We are unable to give the exact dates of these early attempts; but about 1830 Mr. Harrison Dyer, of Boston, Mass., built a steam carriage. The boiler or generator was formed of a coil of half-inch copper tubing, with a small reservoir of steam and water; and it was provided with a circulating pump to keep

a constant flow or circulation of water through the coil. We are unable to state the plan or arrangement of the engines.

About the same time, Mr. Joseph Dixon, of Lynn, near Boston, built a steam carriage, with a pair of engines working on cranks at right angles to each other; which arrangement was new to him. No account is given of his boiler, and other arrangements; but after a short time he satisfied himself that his plan was impracticable.

The next person who tried his hand at steam coaches was Mr. Rufus Porter, of Hartford, Conn. He employed an upright water tube boiler, with a steam chamber at top, and a water chamber at the bottom. His driving wheels were keyed fast upon tubular half axles, with a solid axle running through; and the axles were driven by mitre gearing, like that of Burstall and Hill, so as to enable one wheel to run faster than the other in turning. Mr. Charles W. Copeland, then a youth, used to run this carriage in a field near his father's machine shop, where it was built; and his impression was that a practical carriage might have been made at that time, if the invention had been undertaken with sufficient capital.

In 1834, Mr. James, of New York, built a steam carriage, in which he also employed mitre gearing for

his driving wheels, similar to Mr. Porter's arrangement. The boiler was formed of two concentric cones, with a large grate at the base of the inner cone. The machine ran with considerable speed on cobble pavements, but as it was roughly built, it did not long hold together.

Four or five other steam coaches were built about this time in different parts of the country, but we have been unable to obtain any particulars relating to them. The ill success of these attempts had an unfavourable influence on the use of steam coaches on common roads, and tended to confirm the belief derived from English accounts of the failure of steam carriages.

In 1840, Mr. J. K. Fisher designed a small steam carriage, nearly on the plan of the outside connected locomotives of that time, but with a difference in the plan of constructing the boiler. He was advised by engineers not to pursue the subject further, as the English, on much better roads, had failed.

Twelve years later he resumed the subject, having made some important improvements, and represented his plan as suitable for plank roads. This view was encouraged, and in 1853 he built a small carriage, which when empty weighed 1400 lbs.; it had driving wheels 5 feet in diameter, and two cylinders 4 inches in diameter, by 10 inches stroke.

The boiler was composed of 14 water tubes, each $2\frac{3}{4}$ inches in diameter, set around the fire, and provided with a steam chamber at the top, and a water chamber at the bottom. The carriage attained a speed of about 15 miles an hour on good pavements, but was defective in the strength of some of its joints, and was given up.

In 1858, two self-propelling steam fire-engines were built, the engines and carriages being designed by Mr. Fisher, and the boilers and pumps by other parties. The wheels were 5 feet in diameter, driven by cylinders $7\frac{1}{2}$ inches in diameter, with 14 inches stroke. They were fitted with the stationary link motion. One of these engines, propelled by steam of 180 lbs. on the square inch, ran on the soft ground in the yard of the "Novelty Iron Works;" on cobble pavements, with steam of 100 lbs. on the square inch; and it ran up the steepest inclines in the city, which are about 1 in 20.

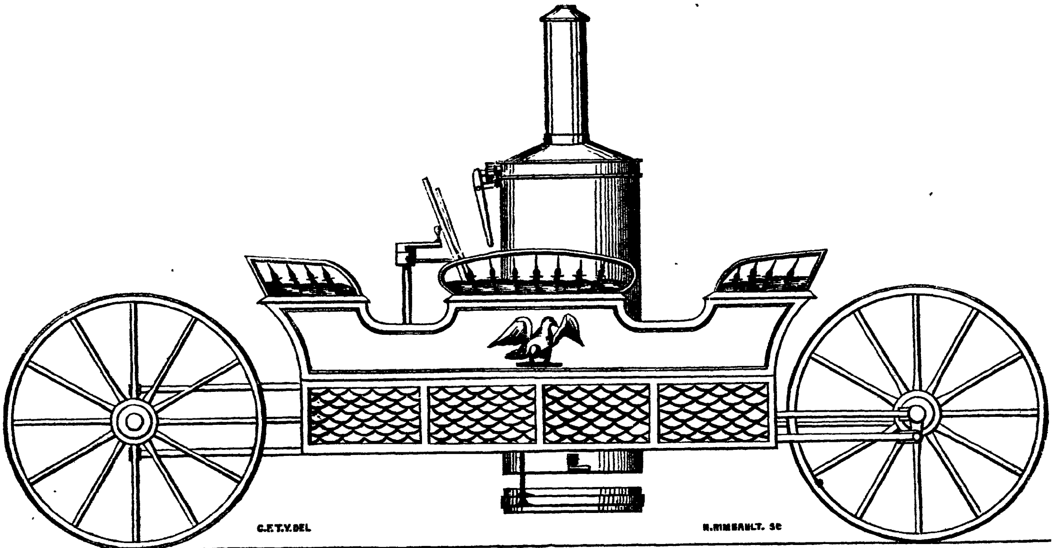
In 1859, Mr. Fisher built a steam carriage, which was so far completed as to be run on a few trial trips. It has 5-feet wheels, two cylinders 7 inches in diameter, by 14 inches stroke, an upright boiler, and its estimated weight, with eleven men on it, is a little over 5 tons, or a weight of 75 lbs. per square foot of heating surface. This engine has run, on a gravel road with a rather loose surface, over the

distance between two milestones, in 2 minutes 40 seconds.

About the same time, another steam fire-engine was built, and fitted with wheels and engines of the same size as the first. The boiler was smaller, and the whole was made much lighter; the tubes of the boiler being extremely thin, and the other parts much lightened. The boiler was of the kind invented by Messrs. Ogle and Summers, tubes within tubes; and the speed of this engine, when tried for a short distance on a gravel turnpike, was at the rate of 18 miles per hour. In all these engines the steam blast has been used, but is found to be too noisy for horses; and for this reason Mr. Fisher intends to use a fan blower.

The principal novelties in Mr. Fisher's plan are, first the parallel connections between the engine crank shaft and the driving axle. The axle is held in place by radius rods, which are jointed at one end to the axle, and at the other end to the boxes on the engine shaft. The joints are partly spherical, to allow of the required motion. The power of the engine is transmitted by parallel rods, as in the locomotives of the "Folkstone" class; the chief difference consisting in the substitution of radius rods for the usual framing.

The effect of this parallel connection is to prevent




Fisher (American), 1859. Fig. 19, Elevation.

the connecting rods from causing the carriage to rock and pitch, as they would inevitably cause it to do, if they acted on the guide bars at one end, and on the wheel at the other—the guide bars being on springs, and the wheels on the road, and the connecting rods acting obliquely. It is understood that the bending of the springs by the action of the engines, was one of the principal difficulties of the early steam carriages; and they were unable to have their engines suspended on easy springs, excepting those worked by gearing chains. The connection of the front axle by projecting springs, taking hold of a Hook's Universal Joint, is another point which is claimed to be advantageous, because it allows high wheels to be used, at the same time keeping a low centre of gravity, and extending the wheel base, so that the drivers may be keyed on, and yet the carriage be sure to turn.

It is steered by means of a screw placed across the front and carrying a nut, to which the end of an elongated reverted pole is jointed. In some instances he has used the screw to operate a crank on an upright shaft, which holds the axle by a Hook's joint in the centre. In the pleasure waggon shown in the drawing (see Fig. 19), the screw is under the floor, on a level with the axle spanner, parallel to the centre line of the carriage, and ten

inches to the left. A nut is turned by bevil gearing, which causes the screw to advance or recede; and a rod connects the screw to the axle spanner. The projecting springs hold the centre of the axle in its position; and the rod, acting on a point about ten inches from the centre, turns the axle either way. The screw works well, and is less liable to be jerked out of position than the pinion formerly used for this purpose. For very light carriages on smooth roads a simple tiller is sufficient; but it is found to be very fatiguing to the hands on rough or uneven roads.

Mr. Fisher's mechanical success has been great, but with the public he has had little; on the contrary, he has had similar discouragement to that met with by the English projectors; excepting that he has not yet come to prohibitory tolls, and heaps of metal on the road; and there can be no reasonable doubt that to the notions so industriously circulated by certain eminent English engineers, that "steam carriages on common roads could never either run or pay," no small amount of this discouragement is due; though it would have been much more to the credit of these English engineers, who so loudly inveighed against steam coaches, if they had *first gained a little practical experience themselves in their working before they so confidently denounced what it turns out so many of them never even saw.*

In following Mr. Fisher through his experiments, we have left behind several others who, within a few years, have made several experiments. Mr. Joseph Battin, of Newark, New Jersey, built a steam carriage in 1856. It had oscillating cylinders 4 inches in diameter, by 12 inches stroke, the piston rods being attached directly to pins in the driving wheels, which were 4 feet in diameter. The framing was very flexible and elastic. The boiler was upright, containing upright tubes, each 15 inches in length. This engine has attained a fair rate of speed upon pavement, but the heating surface is not sufficient for speed on hard or uneven roads. We have seen this at rest, but not running.

Mr. Richard Dudgeon, of New York, built a small locomotive for common roads in 1857. It had cylinders 3 inches in diameter, with 16 inches stroke, bolted to the smoke box; and was inside connected (*i.e.*, had a crank axle, like an inside cylinder locomotive). The driving axle was behind the fire box, and held in place by flexible rods, like Mr. Battin's, and the driving wheels were 42 inches in diameter. The fire box was round, similar to Bury's; and the tubes were 3 feet long. The weight of the engine was about 2,700 lbs. This little engine drew a light barouche, at ten miles an hour on gravel roads, but was unfortunately destroyed by fire at the New

He states that his steam carriages will run on any good hard smooth road, at from 10 to 15 miles an hour, and will carry half their entire freight in passengers, or will ascend hills of 300 feet per mile, or about 1 foot in 20, at an expense for fuel from 6 cents., equal to 3*d.* per hour, or more, according to size. One he had in use weighed 2700 lbs., with water and fuel for one hour's consumption, and from its results he is enabled to give the above statement.

He remarks that by the use of steam carriages passengers and light freight can be carried in less time, as cheap, and more agreeably than in carriages drawn by horses. They are more manageable in crowded streets, do not create filth, nor frighten well-managed horses.

In 1858, Mr. J. W. Fáwkes, of Pennsylvania, built a ploughing drag. The cylinders were 9 inches in diameter, with 15 inches stroke, geared to the six-foot drum, which served instead of driving wheels. The boiler was an upright tubular one, with about 300 square feet of heating surface. The drum was bulged out in the middle like a barrel, so as to enable it to turn easily. It was not mounted on springs, and could hardly be called a road locomotive; but it travelled at from three to four miles an hour over roughish ground without much difficulty, and drew eight ploughs at three miles an hour, over the natural prairie sod.

In the year 1853, and at intervals since, Mr. Stephen Goold, of Newhaven, Connecticut, has experimented on machines for ploughing, and heavy traction. He uses a large wheel, with a small carrying wheel inside—the large one serving as an endless tram. The engines used are very small and run excessively fast. He is said, by those likely to judge favourably, to have been entirely unsuccessful. The boiler used is novel and without tubes, and this may be one cause of his difficulty; but his mechanism is complex in design, and is said to be defective in details of construction.

Mr. Charles Mann, machinist of Troy, New York, has, within three years, built a ploughing drag, the novelty of which consists in a series of iron slabs hinged together, forming a slab chain passing under the driving wheel, and also under a small carrying wheel. The intention is to make a way for the driving wheels to run on. We do not know any particulars as to its performance.

In 1859, Messrs. Necker, Logan, and Reed, machinists of Newark, New Jersey, built a ploughing drag or traction engine on a plan designed by a Mr. Fisher, (not the one before-mentioned). This engine had a locomotive boiler, and large tram wheels, something like those adopted by Mr. Goold. It ran at a moderate speed, as was intended, and had

considerable tractive power. It was considered a satisfactory performance. Mr. Reed considered that the large outside wheels could have been dispensed with without disadvantage.

We have heard of other attempts for the same purpose, but have no definite accounts either of their construction or their performance, we shall, however, we hope, be enabled to enlarge more upon the "History of Steam on Common Roads" in the United States at some future period, when a second edition of this little work is called for.

We find in America that the vertical water tube boilers do not make steam so well as the flue tube boilers (*i. e.* boilers with horizontal tubes). The best result of such boilers here has not been better than that reported by Mr. Ogle, equal to four and one-fifth lbs. per hour per square foot of surface; but we see it stated that Mr. Rickett's flue and tubular boiler has made 15½ lbs. per square foot; and Beattie's, and the old Killingworth boilers have done more.

It is not expected that great economy of fuel will be attained on common roads; the chief aim is to make boilers efficient and cheap. For small carriages we at present expect to find the upright boiler best; but for heavy traction engines we look to the locomotive type. No doubt that if it be possible to make a boiler of water tubes, without large chambers, that

will make steam fast, and can be easily constructed and repaired; such a boiler will greatly promote the application of steam for propelling carriages on common roads.

On street railways there have recently been some trials of steam. Mr. A. B. Latta, of Cincinnati, the first successful builder of steam fire-engines in the United States, has recently built a street locomotive, which is reported to work well and efficiently, drawing a car, or omnibus, with 24 seats, in and upon which 80 persons sometimes ride.

Messrs. Grice and Long, of Philadelphia, have, within a few months, built a steam car for use on the suburban and street railways. It has an upright tubular boiler, of the ordinary type; the cylinders are 5 inches in diameter, by 10 inches stroke; and with gearing making 2½ turns to one revolution of the wheels, which are 30 inches in diameter. The pressure of the steam used is about 50 lbs. per square inch. This car runs its journies in much less time than when horses are used, and draws another car when required.

Messrs. M. Baldwin and Co., locomotive builders, have just finished a steam car for branch and suburban railways, which is constructed to carry 40 passengers. The wheels are 42 inches in diameter, and the cylinders 5 inches in diameter by 12 inches stroke,

coupled directly outside. The boiler is an upright tubular one, situated in a room or chamber at the front end; the hinder end of this car is supported on a "bogie" truck, and its speed on a gradient of 50 feet in a mile, or 1 in 105, is 25 miles an hour, and 35 miles an hour on the level.

In Chicago, Ill., and in Massachusetts, there are five or six steam cars carried on two "bogies;" the engine on the front "bogie," and the boiler in the car, the steam passing down through the spherical joint which connects the "bogie" to the body of the car. These cars have been found economical on branch lines. Many suburban lines of from five to ten miles in length, are worked by horses, at a speed of seven or eight miles an hour, whilst in motion. These cars seat twenty-five, but by an abuse, which the people do not much resist, they carry all who crowd in.

The cost of stopping and starting at this low speed is not so much as to prevent their stopping to pick up or set down one passenger; therefore they stop at every house when required; and the rail being on the old highway gives the advantage of easy traction and cheapness, in addition to the accommodation of the old highway coaches. But it is now desired that the speed should be increased, and that not by means which will involve great

expense in stopping and starting, so that the present accommodation may be continued.

This can only be done by the employment of light steam carriages to run on rails, or trams, or common roads. The old school men generally scout the idea of any better combination than rails and horses; but a few urge the application of steam, and say they will try steam cars when they see them well at work. Hence these attempts at railway steam cars.

The advocates of steam carriages disapprove of the use of rails for suburban traffic, on the ground that they cannot go to every door and accommodate private carriages. It would, they say, be better to to expend upon the flat road all that must be expended on the two systems of rails and flat roads.

If the common roads be not kept up by a large cash expenditure, they will involve greater expense in wear of horses and carriages and loss of time; and if they be kept up to the standard of economy—all interests being considered—the motive power, repairs, and time expended will average less than it can on the compound system.

As the ultimate result of steam carriages, the main suburban roads will be floored with cast iron as smoothly as practicable, with grass up to the edges, entirely free from dust, and free from open

ditches, strong fences, trees, or other things that might injure carriages, in case of their running off the line; on such roads the lightest carriages could be used, and a higher speed could be attained than is safe or even practicable without railways with flanged wheels, and with the heavy machinery deemed necessary for safety.

The carriages that could run on these highways at a high speed, could run on the byways at the speed of horses; and thus there would be an increase of average speed proportionate to the extent of the improved roads; and private as well as public carriages would have the benefit of the improvement.

The cost of iron in America is enhanced by a duty of 30 per cent. Should it be found necessary to use it for this purpose, it is probable the duty would be remitted. If this plan were once established, the plates would be furnished to ships as ballast and thus carried nearly free of charge; and the iron would then cost little more than in Liverpool; and in that case interest and cost of maintenance of an iron-floored road of liberal width, would not exceed the cost of a railway; thus the whole cost of the common road would be saved.

It is in a measure peculiar to America that *cost* is the condition of a public improvement. If the most

sordid system costs less than the most agreeable one, it is difficult to introduce it, not because the people individually are at all sparing in their expenses, but because the politicians apprehend defeat if they increase expenses. They peculate up to the extreme of public endurance, and an increase of taxes, even for the public good, they apprehend would prevent their re-election.

Whilst this is the case the highways will not be on a more liberal plan than the majority of voters, who imagine *they* pay the taxes, are willing to pay for; it is, therefore, necessary to show that the luxurious road is the cheapest, before it will be adopted.

It hardly needs to be added that the steam carriage must begin its career by underworking horses on roads made specially to suit the feet of horses, and that, in consequence of their roughness and softness, have from four to twenty times the resistance that will be found after steam is established, and the roads are made for wheels; whether it is yet able to do this is, to the public, a matter of opinion. A few engineers and experimenters who have *practically* tried it, know that it is able to, and will yet do it.

We do not entertain the slightest doubt that the great economy and convenience of steam traction, when compared with horse, will yet render it of great importance in commercial matters; and it only

requires as much attention to be directed to it as has been bestowed on steam navigation and railways, to render it as great a fact, in a short time hence, as they have become at present; and a fair and unprejudiced trial of a really good and well-designed engine cannot fail to convince the most sceptical of its great importance and numerous advantages.

In this country, as in England, but few engineers have turned their attention to it; but we have not the least doubt that, if, instead of building numberless short branches from the main stems of our railways, to little towns and villages, they were to put on a system of fast steam passenger cars on the common roads, to run at 10 to 14 miles an hour, and carry from 20 to 40 passengers, a very great saving would arise to the railway shareholders, and the travellers between the two places would be equally well served, and nearly as quickly carried.

If public attention and that of capitalists were directed to this subject by the successful working of a given length of road, with an engine well up to its work and built for such a purpose, the principle of propelling by steam on the common roads would make a great start a-head, and doubtless prove a very paying and successful undertaking, especially if properly and carefully managed.

The following article by an American, Mr. Edward

M. Richards, appeared in the *American Railway Review*, of June 21, 1860:—"The opposition with which the road engine was met in years gone by, by those interested in the existing turnpikes of Great Britain, is an instructive instance of the short-sightedness of bigoted mortals, and one that it behoves us of this day to profit by.

"Little did those corporations imagine that in 'killing' the steam carriage they were smiting down their best friend, and building up an opposition that one day was to render almost valueless their property. Nor was the injury confined to them alone—the whole country suffered more or less; in this way, steam being expelled from common roads, men went into constructing railways heels over head; the whole country was checkered over with them; lines were made that never could, by any possibility, pay; and thus was laid, in a great measure, the foundation of those years of panic and monetary distress, that since then have swept over the country like a whirlwind.

"I believe that not only England, but this continent also, would be in a far better condition financially, if neither possessed above half the miles of railway that it does. I know that many hold the opinion that the whole community is the gainer; the more railways are built, though the companies

that construct them may lose by the operations. I do not. Confidence is the soul of business; whatever tends to destroy that, injures the commercial advancement of the country.

"We should to-day be really in a more prosperous situation could we have avoided those late fearful crises, even at the cost of less feverish activity in the years that preceded them. It is just as true of nations as of individuals, that a steady system of moderate labour, continued throughout a lifetime, will produce far greater results than overwork for a season or two, to be followed by a consequent breaking down of the constitution, and giving way of the strength. Years of comparative inaction will then be required to recuperate the powers of the man for a new spasmodic effort, to be followed by the same results; so of whole communities.

"Lines of railway between important places *might* have been splendidly paying investments, and their earnings would have been much increased by the judicious construction of good common road *feeders*, calculated alike for the passage of the predestrian with knapsack on shoulder, the farmer with his team, the road engine with its train of goods or coal waggons, or the steam passenger carriage, with its live freight from the adjacent village to the railway station. In most districts in the northern

and eastern States, abundant means for macadamizing roads in the best manner exist. The road engine, somewhat modified to suit the circumstances of the case, offers admirable facilities for using these materials. It could draw supplies of stone from the various deposits along the line of the turnpike, where the farmers would generally be glad to haul them off their fields, break them up, sort them into the proper sizes, distribute them into suitable waggons, haul the ballast when thus broken to the various parts of the roads requiring repairs, spread it, and, finally—and this is one of the greatest advantages—pass a heavy roller over the newly formed surface, thus causing it to *bind* at once.

"One great trouble with broken stone roads in this country, is the high price of labour; turnpike companies cannot afford to pay men a dollar and upwards a day, to break stones, as they should be broken, for either the construction or repairs of their lines; and, as a natural consequence, we meet 'rocks,' not small stones, as we drive along. Now all this would be avoided by the judicious adaptation of the road engine to the repair work of a turnpike; its untiring steam arm could do all in a far cheaper and better manner than has hitherto been the unsatisfactory product of toilsome manual labour.

"Had this ungratefully treated, but useful servant,

been received as it should, with open arms, in England thirty years ago or more, and its powers developed as hinted at above, our common roads in this country would to-day be very different affairs from what they unfortunately are. If it had been made apparent that they would at some future time be travelled by the steam-horse, the location of them could not have been confided to Tom, Dick, and Harry, whose only object seems to have been to run the lines just where they should not have been, viz., up and down all the hills they could conveniently strike. The laying out and construction of the public roads would have fallen into the hands of those qualified for such tasks, and to whom they properly belonged—the civil engineer of America. In this case they would not be stigmatised as they now are, 'the worst in Christendom.'

"It is well known that the class who have derived most benefit from our multiplication of railways are those who have done the least to help them forward. Not only this, but to whose rapacity and avarice some of the difficulties of companies are due—the *farmers* of the country. They were hostile to this innovation from the very first. Some of us can remember the time when the rifle was brought from its corner to "scare off the railroad surveyors." They have changed somewhat of late years. At

last, having found out that, as they were the benefited parties, and as no more lines would be constructed if the "land damages" robbery system was persisted in, they have so far opened their hearts as to bestow the few acres required for the line. There would have been little of this extortion in the case of macadamized roads, as the landowners would all use them themselves in the ordinary way, and they would have been willing to take stock and help them forward.

"I have long looked on the road locomotive as the *only chance* for improving our public thoroughfares. It seems to be utterly impossible to awaken the community to a sense of the economy that would result from a correct *location* of them, even if the earthworks and stone covering of the surface were delayed until the wants of the people called for expenditure in this respect. At present all there seems possible to do is, to introduce the steam carriage into cities and suburbs, and the traction engine into docks and on wharves, &c. We must get rid of the villainous rail we have at present, and substitute something that ordinary vehicles can use as well as the steam carriage."—*Moore's Ordinary, Va., June 11th,* 1860.

# PASSENGERS BY STEAM ON COMMON ROADS.

## CONCLUSIONS OF COMMITTEE OF HOUSE OF COMMONS.

THE practicability of transporting passengers by steam on common roads, at from twelve to fourteen miles an hour, has been *fully and satisfactorily proved* by Hancock, Gurney, and numerous other persons, within the last thirty years; and as its use at the present time may, *under many circumstances*, be attended with great economy and advantage, *both in this country and abroad*, I purpose to give a condensed account of the results of the enquiry before the Committee of the House of Commons, which sat in 1831, on the subject of steam carriages on common roads, and also to make a few remarks on this subject.

This committee proceeded in the first instance to inquire how far the science of propelling carriages on common roads, by means of steam or mechanical power, had been carried into practical operation; and whether the result of the experiments already

made had been sufficiently favourable to justify their recommending to the House, that protection should be extended to this mode of conveyance, should the tolls imposed on steam carriages by local Acts of Parliament be found prohibitory or excessive.

In the progress of their inquiry, they extended their examination to the following points, on which the chief objections to this application of steam had been founded,—viz., the annoyance caused to travellers on public roads by the peculiar noise of the machinery, and by the escape of smoke and waste steam, which were supposed to be inseparable accompaniments.

They had also to "report upon the proportion of tolls which should be imposed upon steam carriages," and they examined several proprietors of those already in use as to the effect produced on the surface of roads by the action of the propelling wheels.

As this was too important a branch of their inquiry to rest entirely on the evidence of individuals, whose personal interest might have biassed their opinions, the committee also examined several very scientific engineers, by whose observations on the causes of the ordinary wear of roads, they were greatly assisted.

They were also directed to report "on the pro-

bable utility which the public may derive from the use of steam carriages." On this point they examined a member of the committee, well known for his intelligence on subjects connected with the interests of society, and they felt they could not fulfil this part of their instructions better than by referring the House to the evidence of Col. Torrens.

The inquiries made by the committee led them to believe that the substitution of inanimate for animate power in draught on common roads, is *one of the most important improvements in the means of internal communication ever introduced. Its practicability they consider to have been fully established.*

They found, however, that many circumstances would retard the general introduction of steam as a substitute for horse power on common roads, and they recognised one very formidable obstacle in prejudice, which always besets new inventions, especially one which at first appears to be detrimental to the interest, of so many individuals. They found that tolls to an amount which would utterly prohibit the introduction of steam carriages had been imposed on some roads; and that on others the trustees had adopted modes of apportioning the charge, which would be found, if not absolutely prohibitory, at least to place such carriages in a very unfair position, as compared with ordinary coaches.

What some of these tolls are, may be seen in the table at the end of this work.

They also remarked,, that "two courses may be assigned for the imposition of such excessive tolls upon steam carriages. The first, a determination on the part of the trustees to obstruct as much as possible the use of steam as a propelling power. The second, and probably the more frequent, has been a misapprehension of their weight and effect on the roads. *Either cause appeared to the committee a sufficient justification for their recommending to the House that legislative protection should be extended to steam carriages with the least possible delay.*

The committee were of opinion that the *only ground* on which a *fair claim* to a toll can be made *on any public road, is to raise a fund which, with the strictest economy, shall be just sufficient, first, to repay the expense of its original formation; secondly, to maintain it in good and sufficient repair.*

The committee were convinced that the tolls enforced on steam carriages have, in general, *far exceeded the rate at which their injuriousness to the roads, in comparison to other carriages, would warrant.*

In conclusion, the committee stated, that sufficient evidence had "been adduced to convince your committe,"

1st. That carriages *can be propelled by steam on common roads* at an average rate of *ten miles per hour.*

2nd. That at that rate they have conveyed upwards of 14 passengers.

3rd. That they can ascend and descend hills of considerable inclination with *facility and safety.*

4th. That they are *perfectly safe* for passengers.

5th. That they are not (or need not be, *if properly constructed*), nuisances to the public.

6th. That they will become a speedier and *cheaper* mode of conveyance than carriages drawn by horses.

7th. That as the roads are *not acted on so injuriously as by the feet of horses in common draught, such carriages will cause less wear of roads than coaches drawn by horses.*

8th. That rates of toll have been imposed on steam carriages which would *prohibit their being used on several lines of road, were such charges permitted to remain unaltered.*

On Nos. 1, 2, and 3, the accounts given in "Steam on Common Roads," and the accounts of Boydell's engine, will show that the committee had come to a perfectly sound conclusion on these points.

No. 4 is also well proved in the section containing the history of steam on common roads, and it may also be remarked that, in the few accidents, chiefly

arising from imperfect workmanship, little or no damage was ever done.

Relating to No. 5, the evidence given on the Committee of 1859 by Mr. M'Adam, Mr. Gibson, and others on this subject, as well as my own observations on the matter, are a sufficient proof of the non-existence of any nuisance, and I think also that there is no occasion to apprehend any annoyance arising from them.

No. 6 has been so well shown in "Cost of Working," and elsewhere, that there does not seem any necessity to remark more at length upon it.

With regard to No. 7, Messrs. M'Adam and others, in 1859, gave ample proof of how fully this requirement is met by the use of the traction engine, and it may also be remarked that when the Committee of the House of Commons sat, in 1831, and examined Mr. Farey, the engineer, on this point, he remarked,—"If there is *no projection upon the surface of the wheel*, and they are not suffered to drag upon the road, it does not appear to me that any injury can arise more, but rather less, than by common carriages. I should think that a steam carriage would do the least injury, but that is not from experience of steam carriages, but only from my general information, always taking for granted that there is *no projection outside the wheels.* I think the roads will be con-

siderably benefited by the change of impelling by steam instead of by horses. *I think it will be a great public benefit when steam coaches come into common use.*"

Sir J. Macneil observes,—" I should say that the injury roads will sustain by the introduction of steam carriages, will be much less than is commonly supposed. The only damage in my mind that is to be apprehended, is the injury which roads may sustain by the possibility of the wheel, which is acted upon by the engine, turning round without propelling the carriage, in which case the road would suffer considerably; and this would take place if a train of carriages were attached to the engine, the draught of which was more than the friction or gripe of the engine wheel on the surface of the road. As long, however, as the weight is carried by the engine, and not drawn after it, nothing of the kind will take place even on our steepest hills."

Mr. James M'Adam said,—" I am of opinion that a carriage, with *properly constructed wheels,* does less injury to a road than the horses drawing."

Respecting the obnoxious and absurd tolls which some trusts are empowered to charge at the present moment, it must be remembered that the greater portion of them were obtained by a clique of stage-coach men, canal men, and others, whose consciences

allowed them to do anything but tolerate a competition for the traffic on the roads, and who, by means of great exertions of all descriptions, contrived to get these bills "bundled" through the House without opposition, chiefly because those interested in steam coaches were so attentive to carrying out their plans as to give no heed to what was going on; and also from there being so little knowledge in those who suffered them to pass, as to the absurdity of what they were doing, that they passed as a matter of course. It has been said that fifty-four of those bills were brought in at one time, and all passed.

Seeing that these turnpike trusts have had it all their own way with these prohibitory tolls for just *thirty years*, and remembering the old saying that "turn about is fair play," I would suggest the entire suspension of these ridiculous tolls for six years; I would require every engine to be examined by a competent engineer or Government officer, in order to see that its principle of construction did not involve an injurious action on the roads; and I would then encourage, as much as possible, their use on common roads, with the view of finding out what would be a fair toll for them to pay for the use of the road. There surely can be no reasonable objection to urge against a little "free trade" in these close preserves; especially as it

would tend to their own benefit by bringing a large amount of permanent traffic on to their now nearly deserted roads.

Had it not been for an opposition, joined in and sanctioned by Government, of which it has been truly said, that "it would have disgraced a nation many hundred years behind England in civilisation; and the fact that, in this country, prohibitory tolls on steam carriages, to the extent of TWELVE TIMES the amount levied on a stage-coach with four horses, should be allowed to exist, is a circumstance of which any less enlightened legislature *might well be ashamed*," they would long since have been established.

Seeing that it has been satisfactorily proved that steam coaches are capable of travelling with the greatest ease and safety on common turnpike roads, with an economy and speed unattainable by horses on the same road, and as the economy of steam coaches, as a means of transport for passengers, and traction engines for goods, on these roads, has been fully established, to the satisfaction of numerous engineers, and practical and scientific men; when we consider that these trials have been made *under the most unfavourable circumstances, at a great expense, in total uncertainty, without any of those guides which experience has given to other branches of engineering;*

*that those engaged in making them are persons looking solely to their own interest, and not theorists attempting the perfection of ingenious models; when we find them convinced, after long experience and great pecuniary outlay, that they are introducing such a mode of conveyance as shall tempt those interested by its superior advantages to become its employers, it surely cannot be contended that the introduction of steam carriages and haulage on common roads is, as yet, an uncertain experiment, one that ought to be kept off the roads, or unworthy of legislative attention.*

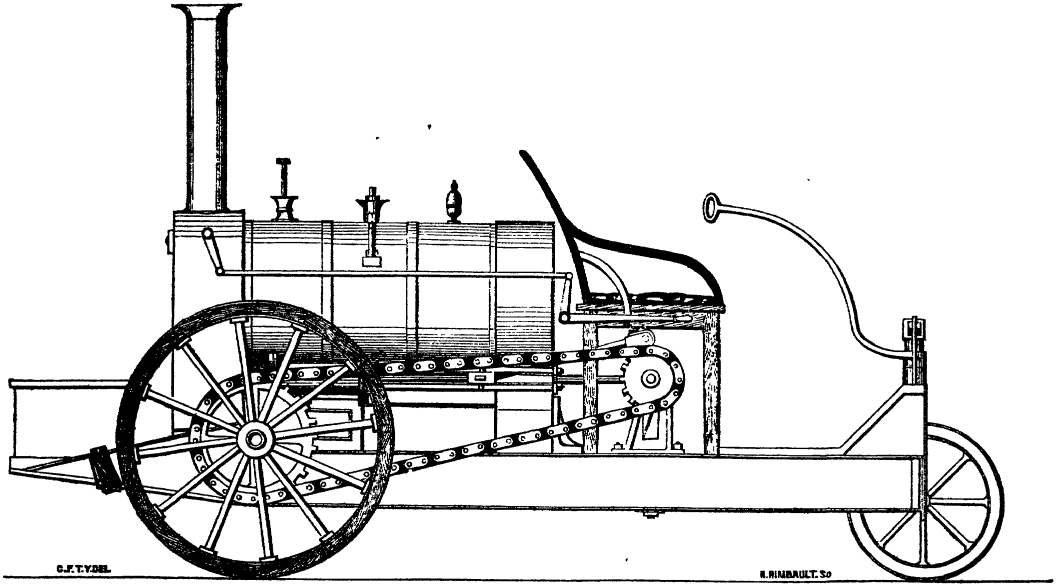
It is a rather amusing circumstance that, with the exception of the fifty odd trusts mentioned in the table at the end of this work, and possibly about a dozen others, on which a toll either more or less extravagant is allowed to be taken; a steam engine can be run on the others throughout England, *without paying any toll at all, a very unfair arrangement.*

What is required is, not that some roads should be exclusive, and others have no power of guarding themselves; but that a fair rate of toll, which would enable the owner of a steam carriage or engine to use it without being too heavily taxed, and the trustees of the roads to have such an amount of toll as would enable them to keep the roads in a proper condition for travelling, and also to pay off the debt

or cost of construction, which alone are the objects for which tolls should be collected.

The subject of conveying passengers by steam on common roads, has received some attention lately in this country, both from engineers and amateurs. The Marquis of Stafford, assisted by some practical engineers, started a small steam coach (Fig. 20) on the turnpike roads in the north of England during the past year, and the following notice of it, from the *Times* of Feb. 11th, 1859, extracted from the *Wolverhampton Chronicle*, gives some idea of it:— "The Marquis of Stafford is in possession of a new kind of steam engine for running on the road. It weighs little more than a ton, and is capable of travelling at from fourteen to sixteen miles per hour. It runs upon three wheels, and is guided by a handle in front, similar to a velocipede. The scheme appears to be a novel one in this district, and will no doubt be the means of opening a field for further inventions of the kind."

The *Engineer*, in noticing the doings of this little engine, says:—"On Monday last (March 7, 1859) Lord Stafford and party made another trip with the little engine from Buckingham to Wolverton. His lordship drove and steered; and although the roads from constant rain were very heavy, they were not more than an hour in running the nine miles to Old




MARQUIS OF STAFFORD, 1859. Fig. 20, Elevation.

Wolverton. This is now the third trip the engine has made from Buckingham to Wolverton and back, twenty miles, beside other runs. His lordship has repeatedly said that it is guided with the greatest ease and precision; in fact, Lord Sefton, who had not travelled with it before, drove it several miles.

"It runs easy, being mounted on springs, and quiet, excepting the roar of steam from the blast pipe; and, as this can be shut off at will, but little difficulty has yet been experienced in meeting horses.

"It weighs 2,134 lbs. light, and 3,360 lbs. when fully loaded; and consumes six to seven pounds of coal per mile, and evaporates one gallon per minute. It was designed by the maker to run at ten miles an hour; one mile in five minutes has been attained, at which it is perfectly steady, the centre of gravity not being more than two feet from the ground.

"On Saturday this little engine started from Messrs. Haye's works, Stoney Stratford (where it had been undergoing some alterations), with a party, consisting of the Marquis of Stafford, Lord Alfred Paget, and two Hungarian noblemen. They proceeded through the town of Stoney Stratford at a rapid pace, and, after a short trip, returned to the Wolverton railway station, whence the engine returned to the works. The trip was in all respects

successful; and shows, beyond a doubt, that steam locomotion for common roads is practicable."

A scheme was started, a short time since, for putting on a line of steam coaches from London to Leeds, which were to run on the old coach road, and open up, by this means of conveyance, a system of traffic to such places on that line as the present railways do not accommodate.

It seems to have been originated by a person who was formerly guard on one of the mail coaches that used to run on that road; and a steam carriage was constructed for him on his own plan, by the late firm of Seaward and Co., some time since.

This carriage has been found to work well, and run at a good rate; but, from the oppressive burden of the present absurd and disgraceful tolls, it has been found impossible to carry out the original intention with any chance of remuneration to those engaged in it; consequently, the matter is still in abeyance.

The *Times* of the 6th of June contained the following remarks on this subject, in the City Article :—"Among the most interesting problems connected with the progress of commercial traffic at the present time, are the facilities to be afforded by tramways for passenger conveyance, and by traction engines for the carriage of heavy goods on turnpike and other

roads. In accordance with precedent, however, the first effort of meddling legislation is, of course, to obstruct the possibility of their introduction. The traction engines of one company have already been frequently employed by manufacturers in the neighbourhood of London for upwards of twelve months, and have worked in all parts of the Metropolis, including the most crowded thoroughfares, drawing heavy loads, sometimes exceeding thirty tons, without a single instance of accident and at a cost alleged to be not more than half of that which would have been incurred for horse-power. No sooner are these results obtained, than Parliament is asked to interfere to deprive the public of the new advantages which promise to be opened up. A bill, entitled the "Locomotive Act, 1860," purposes to prohibit the use of locomotives within four miles of Charing Cross, at all hours, except during the darkness, from midnight to eight in the morning; and this, it may be presumed, would virtually exclude the traction engines from all possibility of being worked at a profit, or so as to suit the requirements of trade."

The above paragraph was followed in the *Times* of the 16th of June, by a letter from Mr. John Gibson, of Manchester, which appeared in the City Article of that paper, headed by the following remarks by the Editor:—"The following relates to tolls on

traction engines, and serves to illustrate the system of obstruction with which every effort to improve locomotion in this commercial country has to contend:—

"'Sir,—I was glad to see, by the observations in your City Article, on Saturday, in reference to traction engines on common roads, that you are coming to our rescue. You are, however, in error in speaking of the present as the first effort of legislation on the subject. The first effort was made as long ago as 1831, when a far more liberal Bill, intended to relieve us from the exorbitant tolls which have ever since prevented our using steam on the turnpike roads, after being referred to a select committee, passed the House of Commons, but does not appear to have gone any further.

"'I am not aware to what extent this prohibition (for such in effect it is) exists in the neighbourhood of London; but I need only mention the fact, that on coals from the collieries at Little Hulton drawn into Manchester, a distance of eight miles, by horses, the turnpike tolls amount to about 3½*d.* per ton; whereas, if drawn by steam, they would, under the existing rates, amount to fully 4*s.* per ton. It was proved, to the satisfaction of the select committee, to whom the subject was again referred in the last Session of Parliament, that traction engines

are now made which do far less injury to turnpike roads than the feet of the horses, which would be so far superseded; and, as the doubt on that subject was the only ostensible excuse for imposing these extortionate and prohibitory tolls, I trust you will give us your powerful aid in removing so unjust and absurd a restriction.

"'Your humble Servant,

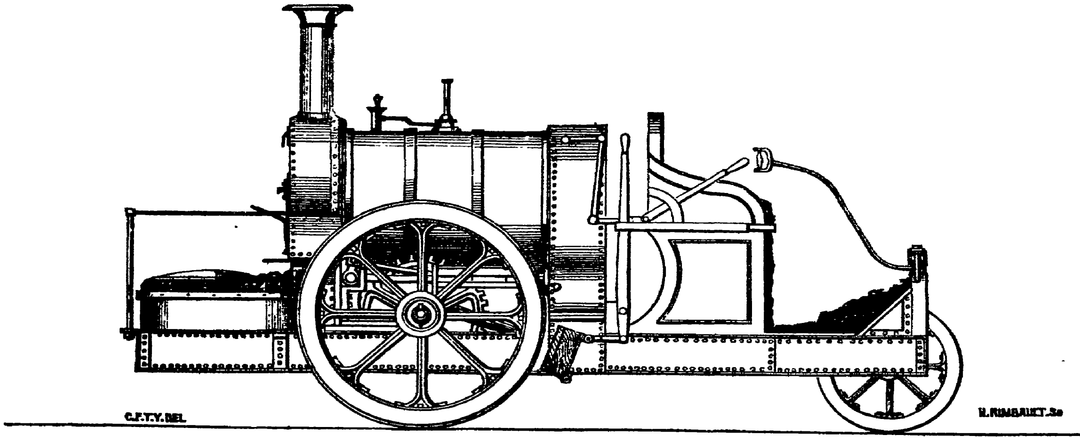
"'JOHN GIBSON.

"'4, Acton Square, Salford, Manchester,
*June*, 12*th*.'"

I fully agree with Mr. Gibson in trusting that the *Times* and the Press will give their powerful aid towards helping to remove these absurd tolls, which could easily be abolished if those members, who now waste the precious time of the House in all sorts of absurdities and twaddle (such, for instance as the late crusade against the Academy Models, &c., so admirably held up to deserved ridicule in *Punch* a short time since), would simply devote a small portion of the time they thus waste on such matters to making themselves practically acquainted with the subject; and the Press could aid its attainment in no small degree by assisting to disseminate facts, and calling public attention to the advantages likely

to accrue from the great facilities afforded by the use of steam on common roads, when applied with judgment and in a proper manner.

The *Times*, of the 1st August, 1860, copies the following from the *Banff Journal*,—"The Earl and Countess of Caithness and Mr. Ross, started from Inverness in his steam carriage (Fig. 21). Owing to its being market day, the road was filled with horses and conveyances of all kinds, but the steam carriage passed through them all without any inconvenience to the general traffic or alarm to the horses. So perfectly was it under control, that it was stopped more quickly than an ordinary carriage and horses could draw up, which was done as often as there seemed any danger of horses being frightened. The run to Beauley, fourteen miles, was done in one hour and twenty minutes, including fifteen minutes for water, and numerous other stoppages. When there was a good length of straight road, eighteen miles an hour was done with great ease. The carriage went up the hills, and down steep declivities, in the most satisfactory manner, and they reached Clashmore successfully the same day, after a run of near seventy miles. The carriage is being run over the steepest roads in Scotland, and is proceeding to Barrogill Castle, a distance of eighty miles."




EARL OF CAITHNESS, 1860. Fig. 21, Elevation.

In concluding the above notice, the same journal remarks,—" His lordship has made this somewhat bold step of applying steam as a propelling power to carriages on common roads for any long distance, and the result of the first day has more than answered the expectations of its warmest supporters, and left no doubt as to its being not only practicable but useful when so applied."

## WHY STEAM TRACTION IS NOT MORE GENERAL.

It is certainly not very difficult to account for the long delay in the employment of steam carriages, both for passengers and the haulage of goods on the turnpike roads, as a substitute for horse-power. The attention of nearly all the scientific men and capitalists having been so entirely absorbed in another species of conveyance, the subject of steam traction on common roads has been comparatively little attended to, and this may in some measure, perhaps, help to elucidate the "why" it has made so little progress, when compared with other modes of conveyance.

The greatest, the most determined, and, at the same time, the most contemptible obstacle it has had to contend with, is PREJUDICE; than this I know of none greater, except it be *impossibility*.

Engineers, as a body, seem to have been wrapped up in the belief that it was "impossible;" and they have not only "believed" it to be so, but have spread and propagated this opinion, with great zeal and perseverance.

Unfortunately, however, for the traction engine, its chief advantage, namely, its *economy in application,* becomes a disadvantage to an important and influential class of persons who are useful in promoting speculative undertakings; because such large profits as are made on locomotive railways, in the shape of law expenses, per centage, &c., cannot be made out of them by lawyers and engineers, from their simplicity and facility of employment, therefore we find all such persons advocating railroads.

Next, the *excessive tolls* on steam carriages, imposed, no doubt, from a determination on the part of the trustees to obstruct, as much as possible, the use of steam as a propelling power, arising from their having the erroneous idea that it *must* be more injurious to the roads than traction by horse-power, has acted in such a manner as to totally prohibit their use in some parts of the country, if put on with a view to making them a profitable investment.

Mr. Gurney, in his evidence before the select committee in 1831, gave, as specimens, the few named under:—

On the Liverpool and Prescot road, his steam carriage would be charged £2 8*s*., whilst a loaded stage coach would pay only 4*s*.

On the Bathgate Road, the same carriage would be charged £1 7*s*. 1*d*., whilst a coach, drawn by four horses, would pay 5*s*.

On the Ashburton and Totnes road, the carriage would have to pay £2, whilst a coach, drawn by four four horses, would pay 5*s*.

Such obstructive, exorbitant, and unreasonable tolls on steam power, can only be justified on the following grounds:—

1st. Because the number of passengers conveyed on or by a steam coach or carriage, will be so great as to diminish (at least to the extent of the difference of the rate of toll) the total number of carriages used on the road; or,

2nd. Because steam carriages induce additional wear and tear, and consequently expense in the repairs of the road.

To the first of these objections the universal and extending employment of railways for passengers and goods, which have removed most of the traffic from the roads, is a sufficient reply; and a thoughtful man would conclude that, with these facts before their eyes, the diminution of the traffic, and consequent loss of interest on the money laid out in the roads, a gross sum has been elsewhere shown of £5,848,645, of which sum £5,038,000 is *bonded debt*, and the rest being made up of floating debt and

unpaid interest; the great and increasing desire of the pubic for cheap transport, if not in cost, at least in time; and, seeing that each new line of railway, when constructed, takes off a greater portion of their traffic, they would only be too glad to welcome and assist any plan for reviving and restoring a small portion of the traffic they are daily losing, especially when that traffic would not lead to greater outlay than at present for maintaining the roads; but here *prejudice* comes into play, and is one of the most formidable (in my opinion the greatest) adversary steam traction has to contend with, seeing that it is not confined to the ignorant unlearned, but is equally shared in by the *quasi*-scientific, or non-practical man, whose dogmatic "it can't be done," or "it won't pay," often strengthens that prejudice when it exists in the minds of those who think they know better than others. To such the remarks of the late Lord Macaulay well apply; they run as follows:—"There were fools then, as there are fools now; fools who laughed at the (endless?) railway as they had laughed at the canals; *fools who thought they evinced their wisdom, by doubting what they could not understand.*"

We can all remember how the late Dr. Lardner, who has been considered a great authority by some people, stated, in a lecture delivered by him in 1836,

that, as for "making a voyage directly from New York to Liverpool, it was, he had no hesitation in saying, *perfectly chimerical!* and they might as well talk of making a voyage from New York or Liverpool to the moon." In spite of this dogmatic dictum, in less than two years, the *Great Western* crossed the Atlantic direct; but I have not yet heard of the easy voyage to the moon.

To any one attentively reading the Report of the Select Committee on Steam Carriages, which sat in 1831, and weighing well the *facts* then elicited (now nearly thirty years ago) as to what was *constantly being done in actual and regular work*, even at that period, when the superb tools, and beautiful and accurate workmanship of the present day, were, as one may say, quite unknown, the question of *why* there should have been no attention given to this subject since, must inevitably suggest itself.

To say that steam cannot be applied for traction on common roads, because a few absurd Acts of Parliament allow of prohibitory tolls being levied on them in some parts of the kingdom, is about as wise as to say that a steam engine could not be made to work, if Government were to put such a tax on coals as would prevent their use except by the richest owners of such engines; and this is precisely the case with steam traction at the present moment.

The idea of a steam engine drawing a heavy load at a speed of twelve miles per hour, was received with ridicule by the most "eminent engineers" of the day.

Mr. Ogle remarked, in his evidence in 1831, that,—"The majority of the London engineers treated our opinions, founded on the laws of nature and experiment, *with contempt and ridicule,* and were amazed at witnessing the vigour of our engines, and the velocity with which we left the factory in Cable Street, Whitechapel, and proceeded towards Southampton. We had no accident of any denomination—not one bolt—not one screw, has ever given way during a period of twelve months, and under circumstances which would have utterly destroyed any other carriage, and very much to the surprise of engineers, *who are sadly uninformed on all points relative to steam coaches, and have never advanced their success.*"

Sir Charles Dance said, when speaking of the opposition he experienced whilst running his steam coach from Gloucester to Cheltenham,—"That obstacles are always thrown in the way of a new invention, particularly if it is likely to produce important results, from the *prejudices of those who have not fairly examined its merits,* and by the opposition of others who expect their interests will be

affected by its success. Thus, objections have been made to these carriages by various descriptions of persons, viz., country gentlemen, trustees of roads, farmers, coach proprietors, coachmen and postboys, &c., &c. Some said they would be injurious to agriculture; others, that they would destroy the roads; others, that removing horses would ruin the farmers; and others, that it would ruin the coach proprietors, and throw all the hands employed out of work."

Sir Charles's engineer (Mr. Stone) observed,—"This is a very bad place to commence on. We are surrounded with prejudiced people; agriculturists, coach proprietors, coachmen, stable-boys, and others directly or indirectly connected with them; these, *with the old ladies* of Cheltenham, I assure you, offer a formidable opposition to any innovation."

It seems that a great many "*old ladies*" some of whom do *not* wear petticoats, and *do not always belong to Cheltenham*, are generally to be found opposing anything new, *whether they understand it or not*, and are just as troublesome in the present day as they were in 1831. If some benevolent individual would provide a "retreat" for these dear old creatures, so as to keep them out of mischief, what a blessing it would be.

The proposition for the use of steam power on the

Liverpool and Manchester Railway excited the alarm of a great number of the shareholders. At the request of the dissentients, two "eminent engineers," the one engaged on public works, and the other *in the manufacture of steam engines,* "investigated" the subject, and, in "a very able document," *proved most clearly* that Mr. Stephenson's project was *practically and commercially inexpedient.*" For some admirable remarks on such a line of conduct, see "Modern Engineering," in the *Engineer* of February 10, 1860.

Mr. M'Adam, in his evidence before the Committee of the House of Commons, in 1859, says,—"Up to the year 1857, I was perfectly convinced that locomotives could never travel upon turnpike roads; but I was then induced to *see* how they were constructed with what is called an endless railway; my curiosity then led me to look at it, and when I saw it, I was so satisfied with the mechanical construction of it, that I saw the company and requested that they would give me an opportunity of travelling with an engine, so that I might see the effect of it, both as to draught, and as to its effect upon the road. They allowed me to do so; and I went to Thetford, and accompanied the engine with a load of some thirty tons, I think, and brought it into London. *It was then in its infancy.* I promised the com-

pany when I went down, that I would keep a log of the proceedings of the engine, and let them have a copy of it. I had previously gone much into the subject with several gentlemen who had suggested engines years before. I had talked a great deal to Mr. Brunel about them, and the conclusion which I always came to, and which Mr. Brunel said was a correct one, was, that the resistance of the road to the engines, which were then suggested, was so great, that there would be no balance of power left to draw the carriages so as to pay."

As far as the subject of tolls on steam carriages is concerned, Farey observed, "that steam coaches will very well bear all the tolls and taxes to which other coaches are subject; *but they want encouragement now instead of difficulties being thrown in their way.* Retardation by small causes is operative to a greater extent than can be conceived. As to the right of tolls on turnpike roads, it should be recollected that turnpike roads *are not property, like canals, but trusts to be exercised for the benefit of the public;* and if it is for the interest of the public that steam coaches should be brought into use, and if that bringing into use will be accelerated by suspending the tolls on them at first, the trustees of the roads ought not to object to such an arrangement; the real amount of tolls they will pay will be an exceedingly small per

centage on the income of their tolls, for as long as steam coaches are losing concerns they cannot be very numerous."

The great mistake which the late Mr. Boydell made, was in attending *first* to the introduction of his engine for *agricultural uses,* and that *so exclusively as almost to prevent its adoption for any other purpose.* He constructed them *as cheaply as possible,* and followed that *exceedingly objectionable practice of attaching the cylinders and working gear to the boiler,* hence those who heard of it simply as an *agricultural implement,* were slow to believe in its utility and great advantages for general haulage purposes; but now that its economy and utility, *under very great disadvantages* (whilst, in the words of Mr. M'Adam, "it was then in its infancy"), have been amply proved and exemplified, there need be no further doubts or uncertainty as to its working, or of its great economy and advantages for traction purposes.

These engines are now being made in a very proper manner. The boiler is *entirely independent of the working parts,* which are attached to a strong plate iron framing, similar to that of a locomotive engine, so that *no strain is thrown upon it,* thus rendering them what they should be, *road locomotives.* The trains of waggons drawn by these engines

are now so arranged that, by means of chains and screw couplings, each waggon is drawn *direct from the engine*, without the strain of the draught being allowed to pass through all the waggons in front of the one drawn behind them, before it reaches it, thus doing away with a great deal of wear and tear, which, with a heavily loaded train, was found to be very objectionable. If, in sending these engines abroad, *proper men* go out with them, and a *correct statement of the circumstances under which they are to be worked has been furnished, so as to enable these requirements to be met*, I am convinced that they will give very satisfactory and profitable results.

## ATTEMPTS TO REDUCE TOLLS.

The successful employment of steam traction engines, during the last two or three years, attracted a good deal of attention to their power and capabilities, chiefly amongst those requiring the removal of heavy weights; but when it was found that such tolls existed in various parts of the country as completely prevented their use, and at the same time other trusts could charge no toll at all, an attempt was made to introduce a Bill to effect some arrangement which would allow of their being employed by such as required them, on the payment of a fair and reasonable toll for the use of the road. Accordingly the following remarks preceded the introduction of the Bill.

It is suggested :—

1. That locomotives are likely to come into common use on turnpike roads.

2. That many local Turnpike Acts do not contain any provision for regulating the same, while, by other Acts, the tolls and regulations are practically prohibitory of the use of locomotives.

3. That the weighing clauses in the General Turnpike Act have not been framed in anticipation of traffic by locomotives, and are, in many respects, ill adapted to the profitable carrying of modern goods traffic, or to the levying of adequate tolls upon carriages drawn by locomotives.

It is submitted :—

That it would be advantageous to the promotion of improved goods traffic by locomotives on turnpike roads, and the levying of adequate tolls, if an Act were passed for the following purposes :—

1. To regulate the construction and use of locomotives on all turnpike roads.

2. To regulate the description and shape of wheels of all carriages drawn by locomotives; as for instance, that they shall be at least six inches on the tire, and that they should be cylindrical.

3. To levy tolls on goods drawn by locomotives; such tolls to be regulated by the tolls leviable upon the like load drawn by horses.

4. To provide for damage (if any) done to roads by use of locomotives, and for disputes, to be settled by the Board of Trade.

In June, 1859, a Bill, was prepared by Messrs. Garnett, Ridley, and Col. Wilson Patten, to regulate the use of locomotives on turnpike roads.

This Bill was ordered by the House of Commons

to be printed, and on the 1st July, 1859, it was published.

In consequence of this, a committee, consisting of Mr. Garnett, as chairman, Col. Wilson Patten, Col. Pennant, Sir William Miles, Sir Robert Ferguson, Messrs. Ridley, Beaumont, Wrightson, Bazley, Mills, Finlay, Caird, Stewart, and Headlam, were appointed to take it into consideration. After adding Mr. Dudley Fortescue to the committee, and having gone into the matter, and examined Mr. M'Adam, Mr. Gibson, and others, it was ordered, "That the Bill, as amended, together with the minutes of evidence, be reported to the House."

This Bill, as amended, was ordered by the House of Commons to be printed, July 22nd, 1859.

The Bill after having passed through the committee was, when brought up for its final reading, proposed by some members to be further altered; but as these persons would not proceed to a division, it was, as had been the case at the former Session, withdrawn in consequence.

It seems that some members consider it a part of their duty to obstruct all attempts at improvement, or the introduction of any new-fangled plans, as they frequently term them; and we see, in this instance, with what success.

When steam carriages were opposed in Parliament,

in 1831, some learned and clever members strenuously opposed them, because they considered that a steam carriage was a *steamboat on wheels!* One would almost fancy some of these "ancient Britons" were still in the House.

It is an utterly hopeless and useless attempt to argue with or endeavour to convince such persons, therefore the best plan is to leave them to their own devices, with the hope that, sooner or later, they will see their absurdity, and then assist in helping forward, what they are now impeding and obstructing.

# CONCLUSION.

In the foregoing pages it has been sufficiently proved, *both by theory and practice,* that steam transport on common roads can be regularly and profitably worked *without injury to the roads,* and that where it is *fairly treated it will pay;* and it now only remains needful to enable those who are so disposed to work these engines and trains at a profit, by assisting to obtain such a fair rate of toll as shall pay for the use of the road, and yet give the user a chance of being paid for his time and outlay; which at present, with things as they are on so many roads, is a total impossibility for any one to do on them, as may be seen by the tolls already quoted; and, in order to obtain this desirable object, I call upon all "free traders" and "reformers" to assist in getting these tolls abolished, so that the charge of "ignorant obstructiveness," which so strongly characterised the period of their imposition, may not be allowed to apply to these "enlightened days,"—these times (so called) of "*liberalism, free trade, and progress.*" And

the opponents of steam traction will do well to remember that, in spite of all opposition, of prejudice, poetry, and abuse, as well as all other known and unknown "preventives," railways, steam, and steam-boats, have "gone a-head," and the public, as usual, have now become their staunchest supporters (the *Quarterly Review* included); and so with steam on common roads; if the Press will aid the cause by the exposition of the advantages to accrue from it, and hasten to make known *facts* as they come to light; if each will lend a helping hand, and, *above all, give the system fair play,* I have no doubt that, before many months are past, we shall find the noisiest of its present opponents its staunchest supporters; and instead of being profoundly ignorant of their own and the public's real interest, as exclusively devoted to its *advancement* as they are at present *to its retardation.*

There can be no doubt that much injury has been done to the cause of steam locomotion on common roads, by the ill-judged and foolish course which has of late been adopted to a greater or less degree by numerous experimenters in this branch of transport, who, claiming to possess advantages and powers which are totally incompatible with common sense, and courting attention on every occasion by advancing the possession of capabilities which did not really

exist, have most signally failed when put to the test, and been left, in numerous instances, floundering about, a miserable example of utter failure.

This has, in consequence, created a certain degree of distrust in the public mind respecting the feasibility of the subject, which will require a little time and a course of successful working to dissipate, so as to convince them that, *when properly carried out, steam traction on common roads is the most economical and advantageous system of transport with which we are yet acquainted.*

A great deal of unnecessary apprehension has been created in regard to the difficulty that is assumed to exist in controlling these steam coaches at speeds of ten miles an hour and upwards. No doubt if they are not properly constructed, and are not managed by men who have been accustomed to steam and locomotives, there may be; but if they are fitted with the link motion, and driven by proper persons, they are far more easily managed, and are far more under control, than any four, three, two, or one horse coach that ever went on a road.

It has long since been practically demonstrated, that steam on common roads, at the rate of from ten to fourteen miles an hour for passengers, and at from three to four miles an hour for goods, can be more safely, easily, and advantageously employed, with a

far greater return for the capital invested, and at a much lower rate of expenditure, than for that of horse-power.

Arguments of the most illogical and foolish nature are used in reference to almost every proposed melioration in our social condition. For example, let the remarks of the opponents to the Bleaching Bill, just passed, be read, and the value of the parties making them be well weighed and estimated. These will doubtless, in a century hence, be quoted for their shortsighted folly, though, at present, they are countenanced by a large class of the community, whose names, in many cases, will go down to posterity to be remembered and held up as samples of the ignorance and selfishness of this "enlightened" nineteenth century.

It should be remembered that we are not called upon to embark in a Utopian scheme to procure the *means*—that might baffle us—and afterwards to devise the *mode*. The former amply provided, we have only to relieve it from the obnoxious and senseless tolls, which at present are such a clog and hindrance to its use, and we have made to our hand a power, and its means of profitable application, that will confer immeasureable benefits, where judiciously applied, on all interested in, or affected by its use, in all parts of the civilised world.

Whatever may be the imperfections in this little work, it is to be hoped that in the absence of any publication giving suitable accounts of the practical working of steam traction engines, from the earliest period to the present day, in this country and the United States, the information and remarks herein collected and embodied, will be esteemed useful by those who are using them, or intend to do so, whether for their own use, or for hiring out to the public.

In the case of those intending to use these engines, some means of knowing what they can do beforehand, to make sure of not being led astray by fancy, cannot fail to be of value; and steam engines being articles requiring some outlay, it must be desirable to acquire such knowledge as a book can give on the subject previous to making a purchase.

Such information as this book does not give, or the consideration of speed or particular cases for their employment, should be referred to the consideration and advice of those, whose practice and experience enable them to become advisers on the matter.

Whilst these pages were passing through the press, an engine and train of six four-wheeled waggons, embodying all the latest improvements, and constructed to order for the Brazils, were, by

the kindness of Her Majesty's Government, allowed to be worked in Hyde Park.

The incessant rains had made the ground in the park quite soft and spongy, but the track of the engine, of about 15 tons weight, and train, of 18 tons, were scarcely more than would be left by an ordinary coal waggon.

In crossing a portion of the park, the ground over an old ballast pit, which had been filled in with some light material, and had left a shell or covering of earth about a foot thick, let the engine suddenly drop in, as into a pitfall; but by removing a small portion of the earth in front of the shoes, to enable them to form an incline, the engine easily walked out, a feat which excited the surprise of the lookers on.

In closing this volume, I shall do so in the words of Mr. Gordon, by "expressing an earnest and fervent wish that the conversion of steam to economic purposes, as a scheme of interest, of duty, of humanity, and morality, will be taken up, and that immediately, by all classes of society with the spirit due to its vast importance.

"The public mind opens, we are aware, but slowly to the advantages to result from the adoption of any novel project; and when the fetters, not merely of *ignorance*, but also of *selfishness*, are to be broken, it may indeed be said, *hic labor, hoc opus est!*

"We are, nevertheless, sanguine that the wonderful realities of steam, as at present exemplified, will not be impotent in relieving the public mind from scepticism as to its almost indefinite utility when directed to any specific purpose.

"The modification in question is one whose practicability and utility alike lie upon the surface; whose adoption can be attended by little partial evil, and be productive of great universal good."

# LIST OF TOLLS.

"What a delightful thing's a turnpike road!—
So smooth, so level;
But onward as we roll—'*surgit amari aliquid*'—THE TOLL!"
DON JUAN, Canto 10, lxxviii.

## TABLE I.

Return of all Turnpike Road Bills which passed the House of Commons in Session 1830-31, wherein any Toll has been imposed on Carriages propelled by Steam or other mechanical contrivance, distinguishing the amount of Toll charged per Horse on Stage Carriages, Vans, Waggons, and Cars, and the Charge on Steam Carriages,

| | Stage Coaches, &c., per Horse. | Waggons, Vans, &c., according to the breadth of the wheels per horse. | Propelled by Machinery. Carriages with two wheels. | Propelled by Machinery. Carriages with four wheels. |
|---|---|---|---|---|
| Bedfont Road | 6d. | 4d., 5d., 6d. | 6d. per wheel for all carriages. | |
| Highgate and Whetstone Road | 6d. | 4d., 5d., 6d. | 1s. 6d. | 2s. 6d. |
| Norwich and Yarmouth Road | 6d. | 4d., 6d. | 2s. for all carriages. | |
| Walsall Roads | $4\frac{1}{2}$d. | $4\frac{1}{2}$d., 6d., 8d. | 2s. 6d. for all carriages. | |
| Stretford Road | 6d. | 6d., $7\frac{1}{2}$d., 9d. | The same toll as if drawn by 4 horses. | |
| Tunbridge Wells and Maresfield Road | 4d. | 2d., 3d., $4\frac{1}{2}$d. | 1s. per ton weight for all carriages. | |
| Birmingham and Bromsgrove Road | $4\frac{1}{2}$d. | $2\frac{1}{2}$d., 3d., $4\frac{1}{2}$d. | For locomotive engines drawing carriages, 2s.; for steam carriages for passengers, &c., 1s. 6d. | |

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| Perry Bar and Handsworth Road ...... | 4½d. | 4½d., 6d., 8d. | 2s. 6d. for all carriages. | |
| Enfield Chase Road ...................... | 4d. | 3d., 4½d., 6d. | 1s. for all carriages. | |
| Lemsford Mill Road ...................... | 7½d. | 6d. | 1s. 6d. | 2s. 6d. |
| Linlithgowshire Roads ..................... | For 1 horse, 1s.6d.; 2 do., 2s.; 3 or 4 do. 4s. | For 1 horse, 6d.; 2 do., 10d.; 3 do., 3s.; 4 do., 4s.; 5 do., 6s.; 6 do., 8s. | 1d. per cwt. for all carriages. | |
| Coventry and Over Whiteacre Road ... | 3d. | 2d., 3d., 4d. | 2s. 6d. for all carriages. | |
| Watling Street Road ..................... | 4½d. | 4d., 5d., 6d. | Ditto ditto. | |
| Pinwall Lane Road ...................... | 4½d. | 4d., 5d., 6d. | Ditto ditto. | |
| Worthing and Littlehampton Road ... | 6d. | 4d., 5d. 6d. | 1s. per wheel for all carriages. | |
| Leeds and Birstall Road ................. | 8d. | 6d., 7½d., 9d. | 2s. per wheel for all carriages. | |
| Haslemere Road ......................... | 4½d. | 4½d. | 1s. | 2s. |
| Macclesfield and Nether Tabley Road | 6d. | 6d., 8d. | 9d. per wheel for all carriages. | |
| Glamorganshire Roads ................... | 6d. | 6d. | 1s. 6d. | 3s. |
| Cleeve and Evesham Road ............... | 9d. | 9d. | 1s. 6d. | 3s. |
| Pucklechurch Roads ...................... | 6d. | 6d., 7½d., 9d. | 1s. per cwt. | |
| Leicester and Welford Road ............ | 4½d. | 3d., 3½d., 4d. | 1s. for all carriages. | |
| Lampeter Roads ......................... | 6d. | 4½d., 5½d., 6d. | The same toll as if drawn by 4 horses. | |
| Llandovery and Llangadock Road ...... | 6d. | 4½d., 5½d., 6d. | Ditto ditto. | |
| Bathgate Roads ............................ | 1s. 3d. | For 1 horse, 9d.; if more than 1, 6d. per horse. | 2s. 9d. for all carriages not exceeding 25 cwt. | |
| Titchfield and Cosham Road ........... | 6d. | 3d., 3¾d., 4½d. | 2s. per wheel for all carriages. | |
| Cheadle Roads ............................ | 6d. | 4d., 5d., 9d. | 5s. for all carriages. | |
| Bruton Roads ............................. | 6d. | 4½d., 6d., 7½d., 9d. | 4s. for all carriages. | |
| Coventry and Stoney Stanton Road ... | 3d. | 4d., 5d., 6d. | 2s. 6d. for all carriages. | |
| Liverpool and Preston Road ........... | 6d. | If drawn by 4 or 5 horses, 1s., 1s. 5d., 2s. 3d., 2s. 5d.; if by 2 or 3 horses, 4d., 6d., 8d. | If not exceeding 1 ton, 6d. per wheel, and 6d. per wheel for every further ton weight. | |

## TABLE II.

**Return of all Private Bills which have passed the House of Commons wherein any Toll has been imposed on Carriages propelled by Steam or other mechanical contrivance, distinguishing the Amount of Toll charged per Horse on Stage Carriages, Vans, Waggons, and Cars, and the Charge on Steam Carriages.**

| | Stage Coaches, &c., per Horse. | Waggons, Vans, &c., according to the breadth of the wheels. | Propelled by Machinery. | |
|---|---|---|---|---|
| | | | Carriages with three, or a less number of wheels. | Carriages with four or more wheels. |
| Kidwelly Roads | 6d. | 4d., 5d., 6d. | 2s. for two-wheeled carriages. | 3s. |
| Lynn (East Gate) Road | 4d. | 3d., 3¾d., 4½d. | 2s. 6d. for all carriages. | |
| Lynn (South Gate) Road | 4d. | 3d., 3¾d., 4½d. | Ditto ditto. | |
| Handsworth Road | 6d. | 6d., 8d., 9d. | The same toll as if drawn by 4 horses. | |
| Aylsham Road | 3d. | 2d. | 9d. | 1s. 6d. |
| Cheltenham Roads | 8d. | ... ... | 3s. for all carriages. | |
| Liverpool and Prescot Road | 1s. 6d. and 1s. | 6d., 8d., 10d., 1s. | 1s. 6d. for every horse power for all carriages. | |
| Abergavenny Roads | 6d. | 8d., 9d., 1s. | The same toll as if drawn by 4 horses. | |
| Drogheda Roads | 6d. | 2d., 4d., 6d., 1s. | The same toll as if drawn by 2 horses. | |
| St. Alban's Road | 6d. | ... ... | 1s. 6d. | 2s. 6d. |
| Sunderland Roads | 4½d. | 3d., 4d., 9d., 1s. | 6d. for every horse power for all carriages. | |
| Wisbech and Thorney Road | 6d. | 3d., 3¾d., 4½d. | 2s. | 4s. |

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|---|---|---|---|---|
| Frome Roads | 6d. | 6d., 7d., 8d. | 2s. for all carriages. | |
| Huddersfield and Woodhead Road | 6d. | 3d., 4d., 4½d. | 2s. 6d. for all carriages. | |
| Wakefield and Austerlands Road | 6d. | 4d., 5d., 6d. | Ditto ditto. | |
| Monmouth Roads | 8d. | 5d., 6d., 7d., 1s. | 1s. 6d. | 2s. 6d. |
| Wakefield Ings Road | 3d. | 1d., 1½d., 2d. | 6d. | 1s. |
| Stirlingshire Roads | 1s. 3d. | If not exceeding 25 cwt., 9d.; if between 25 and 30 cwt., 1d. in addition, and so on in proportion. | 2s. 6d. for every carriage not exceeding 25 cwt.; if between 25 and 30 cwt., 1d. per cwt. in addition, and so on in proportion. | |
| Exeter Roads | 8d., 9d. | If drawn by 1 horse only, 9d.; if by 2 or more horses, 6d. per horse. | If not exceeding 1 ton, 6d. per wheel; if more than 1 ton, 6d. per wheel in addition, and 6d. per wheel for every further ton weight. | |
| Teignmouth and Dawlish Road | If drawn by 2 or 3 horses, 8d.; if by 4 or more, 6d. | 9d. | If not exceeding 1 ton, 6d. per wheel; if more than 1 ton, 4d. per wheel in addition, and 6d. per wheel for every further ton weight. | |
| Darlington Road | If drawn by 2 or 1 horse, 10d.; if by 4 horses, 8d.; and if by 6 horses, 6d. per horse. | 6d., 8d., 10d. | 1s. | 2s. |

Private Bill Office, House of Commons,
*August* 22, 1831.

EDWARD JOHNSON.

*The following works contain much interesting information on the subject treated of in this work:—*

Parnell on Roads.

Gordon on Elemental Locomotion.

Wood on Railroads.

Galloway and Hebert on the Steam Engine.

Hancock's Narrative.

W. Bridges Adams on Pleasure Carriages.

Railway Economy.

Our Iron Roads.

Hebert's Encyclopædia.

Evidence of Committee of the House of Commons, 1831 and 1859.

Engineers' and Architects' Journal.

Mechanics' Magazine.

Repertory of Arts.

Artizan.

Practical Mechanics' Journal.

Patent Journal.

LONDON:

PRINTED AT THE SCIENTIFIC PRESS, 5, SALISBURY STREET,
STRAND, W.C.